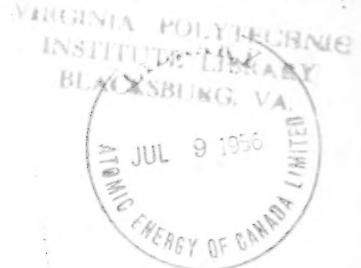


Design Engineering

FIVE DOLLARS A YEAR



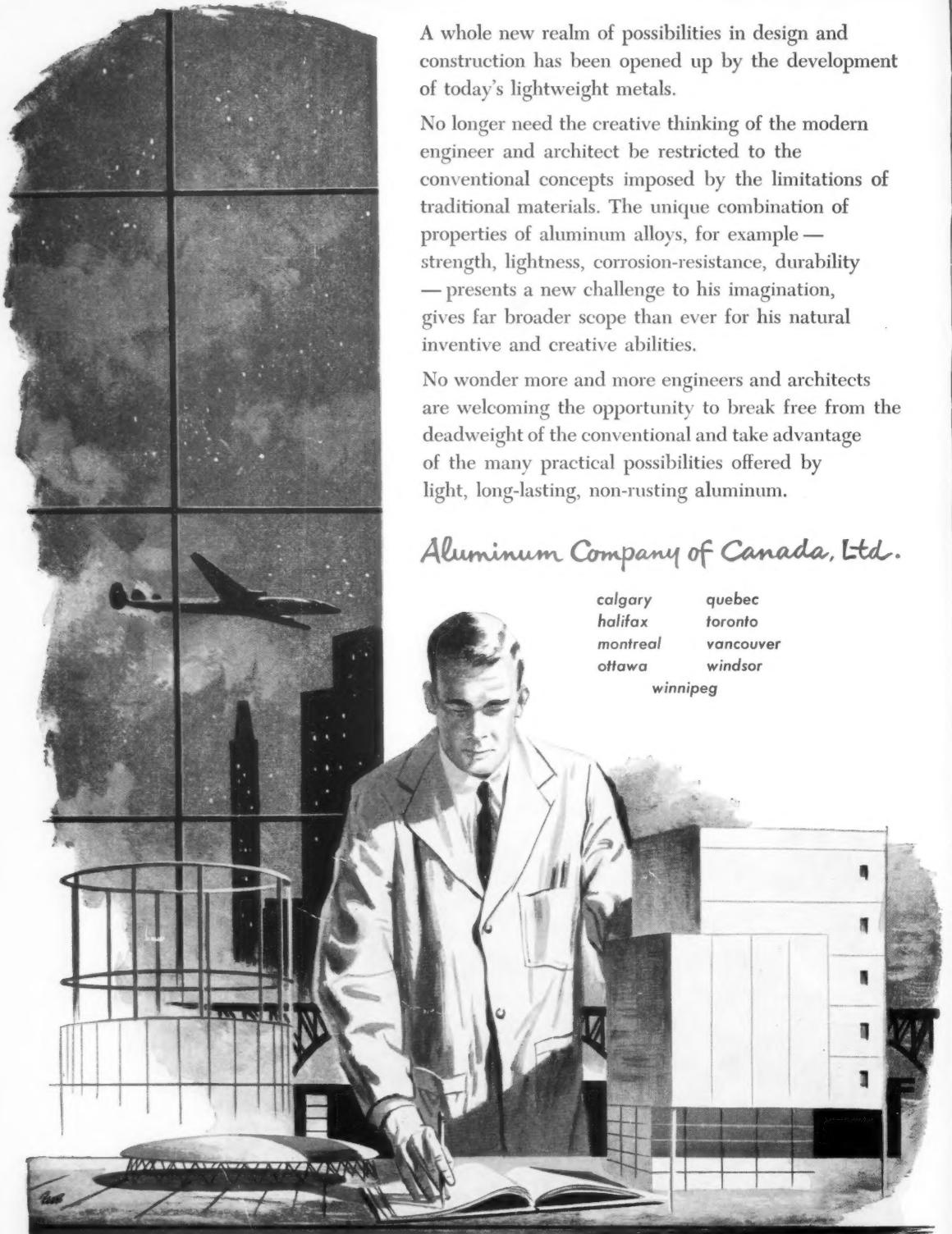
HOW TO CHOOSE A MINIATURE BEARING (page 42)

Cars without carburetors are nearly here

July 1956

Metal stampings can be improved

Breaking free from the fetters of convention



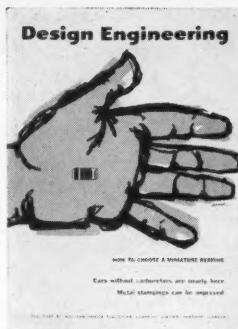
A whole new realm of possibilities in design and construction has been opened up by the development of today's lightweight metals.

No longer need the creative thinking of the modern engineer and architect be restricted to the conventional concepts imposed by the limitations of traditional materials. The unique combination of properties of aluminum alloys, for example—strength, lightness, corrosion-resistance, durability—presents a new challenge to his imagination, gives far broader scope than ever for his natural inventive and creative abilities.

No wonder more and more engineers and architects are welcoming the opportunity to break free from the deadweight of the conventional and take advantage of the many practical possibilities offered by light, long-lasting, non-rusting aluminum.

Aluminum Company of Canada, Ltd.

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montreal vancouver
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 winnipeg



This month's cover

The lead feature on miniature ball bearings is symbolized on this month's cover. Artist Don Dancer felt that the best way to emphasize how really small these bearings are was to show a miniature ball bearing in relation to a well-known object. And what could be more well known than the human hand. In the article itself a photograph shows dramatically how miniature ball bearings compare in size with an ordinary drawing pen.

Design Engineering

MEMBER

CCAB

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Design Engineering

VOL. 2

JULY 1956

NO. 7

CONTENTS

Features

When will fuel injection be ready	27
More economy with metal stampings	32
Use this new electronic harness rocker	34
Mass produce with the base plate method	36
Use sintered aluminum pulver or SAP	40
How to select miniature ball bearings	42
Laminated plastics fulfill a design need	48

Short features

Nylon tube bending mandrels save time	47
Try this variable speed transmission	50

Departments

Reports from industry	5, 66
People	25
New products	60, 62
Design in pictures	70
Patents	56
File (brochures offered)	68
Quotes from papers	71, 80
Readers' letters	76

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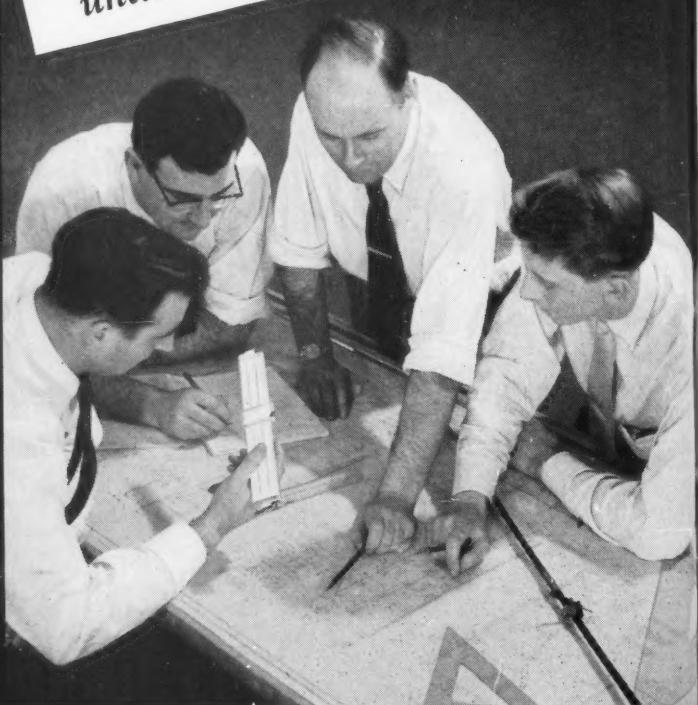
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Design Engineering

Inside

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The August issue of Design Engineering will carry strong feature articles written by contributors no less experienced than those featured this month.

The lead feature deals with the subject of Cypak control systems, which accomplish the same results as relays through what is known as a logic function approach.

There will also be an article on electronic stroboscopes. These are used for measuring speeds and for studying periodic motion (rotational or reciprocating), by presenting to the observer a series of accurately timed images.



Dinges



Strasser



Carter



Last

William A. Dinges wrote the watch base plate article. He is a graduate in mechanical engineering from Villanova College, is 40 years old and has been with the Hamilton Watch Company, Lancaster, Pennsylvania, for fifteen years. He is a senior process engineer and spent considerable time as a supervisor in the fuze manufacturing department. His experience in all phases of processing instrument components, such as base plates, wheels, pinions, gears, arbors, and so forth, makes him well qualified, from a technical and practical viewpoint, to write this article on base plates.

Author of the article on metal stampings, Federico Strasser was born in Budapest in 1906. After graduating from high school, he went to Milan to study electrical engineering and held a few jobs, both in Milan and in Cologne, specializing in the manufacture of electrical wiring devices. Since 1939 he has lived in South America and is a partner in one of the leading factories for electrical and plastic articles

R. H. Carter, Chief Engineer of the Miniature Precision Bearings, Inc., Keene, N.H., has been associated with the company for 16 years. During this time he has been instrumental in development of the many new types of miniature ball bearing introduced by the company. In his present position he is responsible for all phases of ball bearing engineering, including design and user application services. A mechanical engineering graduate of the University of New Hampshire, Carter is a registered professional engineer and a member of the ASTE

The author of the article on sinter-aluminum-pulver (SAP) joined the Ontario Research Foundation in 1951 as a metallurgist. In 1952 he became connected with the physical testing of controlled density steel (a steel making process developed at the ORF). This was under a Fellowship of the Defence Research Board. After becoming a member of the ASTM Committee B-9 on powder metallurgy in 1952, he initiated a mineral dressing department in the ORF to deal mainly with iron ores and their magnetic concentration.

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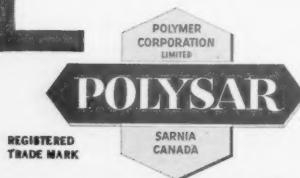
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Reports

News in brief from the world's producers

LONDON, ONT.—Head office and manufacturing facilities of Micanite Canada, Ltd., recently acquired by Minnesota Mining and Manufacturing Company, have been moved from their location at Granby, Que., to the 3M plant at London, Ontario.

M. H. Patterson, vice-president and general manager of both companies, announced that consolidation is complete. Production of fabricated laminated plastics and micaceous products, for use in the electrical and electronics industries, has begun in the new location.

Passports for welders

TORONTO—Welding operators have always wanted two things. One, that facilities be made available for them to take a welding test on their own initiative to prove their skill and competency, and the other, that their ability be recognized by an official certificate.

Just such an official certificate is now available through the Canadian Welding Bureau in the form of an employment and qualification record book. Because this book looks so much like a passport, because it officially recognizes the operator and because it permits him to move from firm to firm, usually without additional testing, it has already been dubbed "The Welder's Passport."

The Canadian Welding Bureau has always been sympathetic to these two desires on the part of welding operators and now that the second has been achieved, perhaps the first will follow more readily.

Some years ago, as a step to official recognition, the bureau started to issue identification-transfer cards. These were valuable both to operators and employers, since they permitted welders to transfer from one firm to another without additional testing. Unfortunately, however, they could be issued only to operators who were employed by certain "approved" firms.

The same situation applied to those tested by the Provincial Department of Labor for pressure vessel work. Consequently the number holding any form of certificate was limited and the great majority of operators had nothing to testify to their skill and proficiency. Men who had a wealth of experience in different industries, with different metals and different processes, often had less to show than the youngster who had

just received a diploma after attending a welding school for a few weeks or months.

Naturally, employers preferred operators with some proof of their ability and insisted, where possible, on hiring those with cards or, in other words, those who had been fortunate enough to be employed at some time with a firm engaged on work that demanded their approval.

This was not quite fair and some time ago the Canadian Welding Bureau set out to rectify the situation as far as conditions and regulations would permit.

ASTM meeting

ATLANTIC CITY, N.J. — Forty leading manufacturers and distributors from Canada and the United States, as well as representatives of European companies, took part in the 12th exhibit of testing and scientific apparatus and laboratory supplies held last month at Atlantic City, N.J., in connection with the 59th Annual Meeting of the American Society of Testing Materials.

On display were hundreds of items, including small hand-manipulated instruments, electronically controlled devices, high temperature ovens and universal testing machines. The exhibitors made every effort to develop a show that gave an opportunity for the research scientists, educators, testing and materials engineers attending the meeting to see the latest in testing and research apparatus.

The technical sessions, of which there were 32, covered a wide variety of subjects relating to research and testing of engineering materials.

In addition, individual papers were given on such subjects as rheological problems, metals, fatigue, stainless steel and general testing.

The Marburg Lecture was given by Dr. Charles E. Reed, general manager Silicone Products Dept., General Electric Co., Waterford, N.Y., on "The chemical properties and applications of silicones." Dr. D. K. Crampton, director of development, Chase Brass and Copper Co., Waterbury, Conn., gave the Gillett Memorial Lecture on "Structural chemistry and metallurgy of copper."

Test lab. opened

TORONTO—The first Canadian privately sponsored environmental test laboratory was recently opened at the PSC Applied Research plant. Main figures in the ceremony, marking the Hunting Group's ten years in Canada, are shown grouped around an electromagnetic shaker for reproducing the effect of vibration at supersonic speeds. They are (left to right): Dr. O. E. Braaten, head of the laboratory; D. N. Kendall, founder and operating head of the Hunting companies in Canada; J. M. Bridgman, general manager of PSC Applied Research Limited; Air Commodore Hodson; and Bill Wilson, laboratory technician.

Other testing equipment in the laboratory, offered to Canadian industry for the first time, includes an icing wind tunnel, altitude temperature chambers, shock, salt fog and radio interference tests. New equipment being added shortly will test the effects of sand and dust.

(Continued on page 66)



Electromagnetic shaker at PSC environmental test lab.



Designers' Guide for Selection of Hose Lines

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TYPE OF FLUID	AEROQUIP HOSE NUMBER																									
	1501	150101	1502 (Buna N)	1502 (Neop.)	1503 (Buna N)	1503 (Neop.)	1508	1508 (Buna N)	1509A (Neop.)	1513	1524	1525	1531	1532	1533 (Buna N)	1533 (Neop.)	1538	1540	1541	1546	1547	2556	2550	2551	2750	
Acetic Acid (conc.)	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	
Acetic Acid (dil.)	○	●	○	●	○	●	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Acetone	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Acetylene	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Air	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Air, Hot	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Alcohols, Aliphatic	●	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Ammonia, Anhydrous	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Ammonia, Aqueous	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Ammonia Gas	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Asphalt	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Benzene (Benzol)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Butane	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Carbolic Acid (Phenol), Hot	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●
Carbon Dioxide (dry)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Chlorinated Solvents	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Chlorine (dry)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Chlorine (wet or solutions)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Creosote Oil	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Diesel Fuel	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Ethers	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Freon 12, 13	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Fuel Oil	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Furfural	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Gasoline, Refined	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Gasoline, Sour	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Hydraulic Oil	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Hydrogen	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Hydrolube	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Kerosene	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Ketones	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Lacquers and Solvents	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Lindol, Cellulube	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Lube Oil (hot)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Mercury	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mineral Oil	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Naphtha	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Naphthalene	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Natural Gas	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Oxygen	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Propane	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Pydraul F-9	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●
Steam	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Trichlorethylene	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Toluene (Toluol)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Water, Fresh and Salt (cold)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Water, Fresh and Salt (hot)	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

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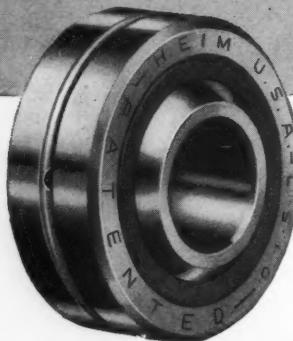
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The single ball (Unibal) construction, because of its free action, compensates for shaft misalignment and deflections in all directions. There is ample provision for lubrication around the ball, and the greater supporting area carries heavier loads.

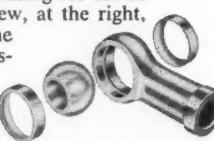


This is the Heim Unibal Rod End. It operates on the same principle, but is mounted in a suitable housing for use in push-pull applications. The exploded view, at the right, shows the two bronze bearing inserts (the race) ready to be expanded into the housing and around the ball.



Heim Unibal Spherical Bearings are available in a wide range of stock sizes, the Rod Ends are made in both male and female types, and complete stocks are carried by bearing distributors throughout the country.

It is not only the low price of the Unibal Rod End, but the simplicity of attaching it that bring the overall cost down. Many applications require only a drilled and tapped hole for the male rod end — or a drilled hole, with a bolt or screw for the female type.



Please write for complete catalog and name of nearest Direct Factory Representative or Distributor. Heim Unibal is also manufactured, under license, in England, Germany, Switzerland and other European countries.

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"Good" is the measure of performance. A good casting measures up—in performance—to all the requirements of its buyer and its end user.

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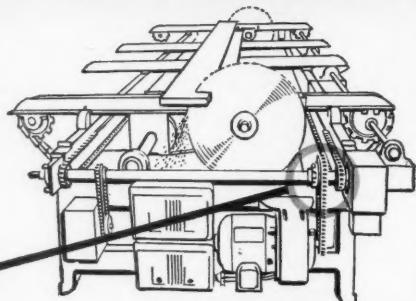
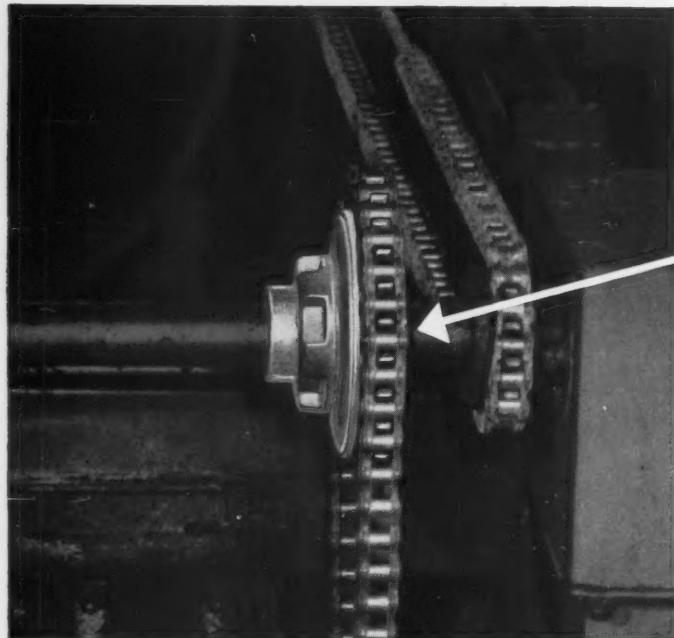
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Typical application shows how you can safeguard drive units and eliminate shear pins

Check these advantages of Morse Torque Limiters

- ✓ Eliminate downtime
- ✓ Torque-sensitive and fully adjustable
- ✓ Completely automatic and dependable
- ✓ Resume operation automatically
- ✓ Compact, standard sizes

In this Wheland Electric Shift Trimmer, two 200-pound saw arbors are automatically moved into position at 120 feet per minute... then stopped dead and locked into place.

The tremendous shock transmitted to the drive mechanism when the arbors are stopped, is safely dissipated by a Morse Torque Limiter used as a slip clutch between the driving and driven units. In addition, it prevents motor inertia from building up torque in the drive.

Versatile Morse Torque Limiters

can safely control many of the shock-load problems present in your machine operations.

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5
SIZES

AC RATINGS

AMP	VOLTS	NO. TAPS
10	150	2 to 11
15	150	2 to 12
25	300*	2 to 12
50	300*	2 to 12
100	300	2 to 8

*150 Volts between taps.

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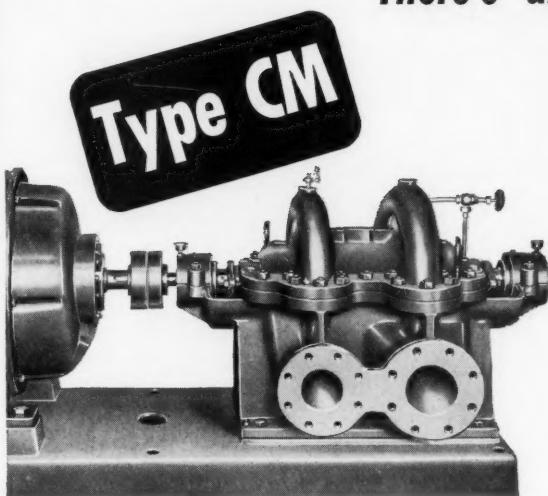
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Critical Service?
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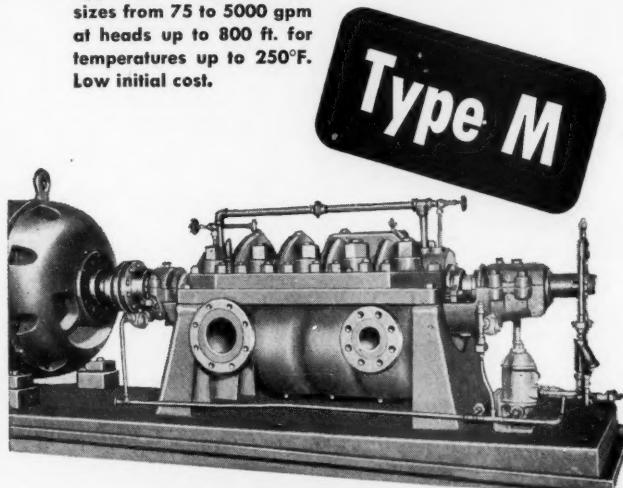
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There's an **ALLIS-CHALMERS**
Multi-Stage Pump
to fit your needs



Type CM — Available in sizes from 75 to 5000 gpm at heads up to 800 ft. for temperatures up to 250°F. Low initial cost.



Type M — Capacities range from 75 to 1000 gpm or more at heads from 400 to 2100 ft. for temperatures up to 400°F. Optional features include water-cooled stuffing boxes, ring oiled ball bearings with water jacketed housing, forced oil lubrication with cooler, ball, sleeve or Kingsbury bearings.

Allis-Chalmers manufactures a complete line of multi-stage pumps for every type of application: high pressure mine service, boiler feed service, bulk storage transfer, oil refinery service or municipal water supply.

These great features apply to both the low initial cost Type CM pump and the Type M pump for critical service:

- Small, easily replaceable low-cost parts take all wear. Casing does not form running surface.
- Double-suction impellers eliminate end thrust and sudden shock load from flashing. No special balancing device necessary.
- Horizontally split casing permits easy maintenance to rotating element without disturbing piping or motor.
- Stuffing box pressure equalized — reduces wear on shaft, sleeve and packing.
- Mechanical seals and smothering glands optional.

Call your nearest CA-C Sales Office to have an experienced engineer go over your pumping plans with you, or write direct to Canadian Allis-Chalmers, P. O. Box 37, Montreal, Que., for bulletins CAC6009 and CAC6040

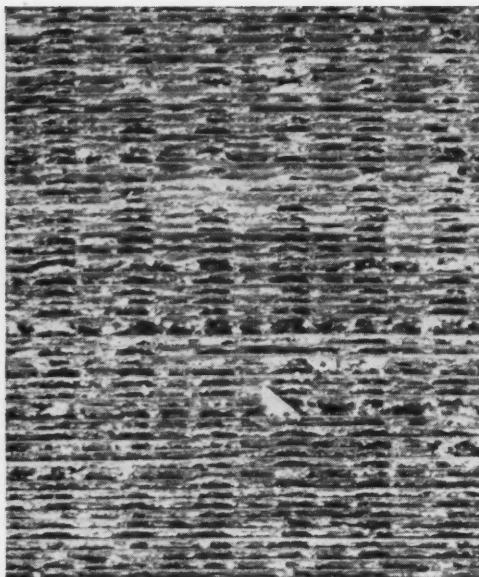
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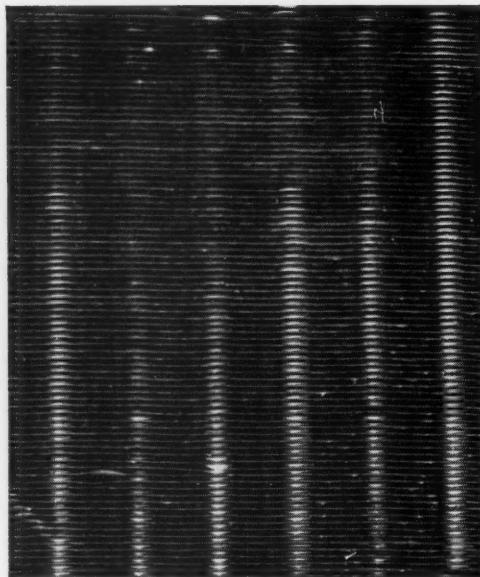


55-CAL-6

1150-hour salt spray test shows increased corrosion resistance with Bonderite on aluminum



UNTREATED. Unretouched photo of section of aluminum refrigeration air conditioner condenser after 1150 hours in salt spray. Note corrosion.



BONDERITE-TREATED. Unretouched photo of identical aluminum refrigeration air conditioner condenser after 1150 hours in salt spray. Note absence of corrosion.

If you want more effective bare corrosion resistance or increased durability for paint, treat aluminum and its alloys with Bonderite.

Special formula Bonderites have been developed and tested and proven thoroughly for this purpose. They form a thin, iridescent, remarkably effective integral coating with the aluminum in simple and economical operation. Solutions are sludgeless, easily controlled, and produce results of uniform high quality.

The Bonderite coating is flexible, withstanding moderate draws without trouble. The coating con-

ducts electricity, necessitating no change in arc and spot welding procedures. Bimetallic and galvanic corrosion resistance is high.

Applications are many and varied. Aircraft, automotive, air conditioning, refrigeration and strip stock fabrication are a few of the industries which are finding it extremely useful. 700 Series Bonderites meet the requirements of MIL-C-5541.

Get complete information on this more effective protection for aluminum and its alloys. Write for bulletin on Bonderite 710 and 720.

*Bonderite, Bonderlube, Parco, ParcoLubrite—Reg. U.S. Pat. Off.



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corrosion resistant
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Using

DU PONT ELASTOMERS NEOPRENE - HYPALON

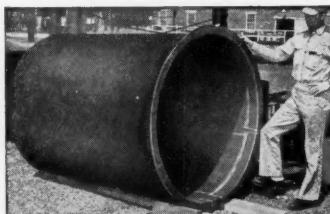


in Design

HYPALON tank linings for strong oxidizing agents

Now a wide range of chemicals can be safely handled by storage tanks and shipping containers for long periods. The secret is a lining made of HYPALON, Du Pont's new synthetic rubber. Tank linings of HYPALON have extra-high resistance to chemicals—even the strongest oxidizing agents have little effect on linings of HYPALON.

But exceptional chemical resistance is just part of the story: HYPALON also withstands temperatures from 250°F. to 350°F. It is completely unaffected by ozone and can take prolonged exposure to weathering and sunlight without deteriorating.



TANK LINED with HYPALON for storage of calcium hypochlorite. HYPALON is applied by standard lining methods, adheres firmly.

HYPALON can provide extra-high durability to products exposed to severe service conditions; such as hose for handling strong acids and hot fluids; gaskets and packings in high-temperature service; protective coatings for metal and masonry; and many others. To become acquainted with Du Pont HYPALON—just clip and mail coupon.

Flexible NEOPRENE idlers for conveyor belts outlast steel idlers better than 8 to 1

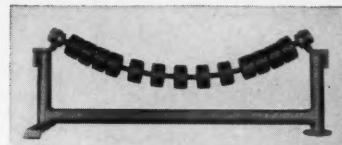


NEOPRENE IDLERS are still in service after two years. Accumulated sand previously fouled the steel idler bearings, stopped the idlers and damaged the belt. Average service was three months.

NEOPRENE resists abrasive action of sand, retains its flexibility

At one point in the production of castings at a magnesium foundry in the Midwest a conveyor belt carries molding sand from a chute up a 35° incline to another belt. Sand builds up under the belt. When the belt ran on steel idlers, sand fouled the bearings, jammed the idlers and damaged the belt. Average service life of the steel idlers was three months.

The manufacturer decided to install flexible idlers made of neoprene. The new idlers, developed by Joy Manufacturing Company, consist of neoprene discs permanently bonded to a flexible neoprene-sheathed steel cable and suspended from a single sealed bearing at each end. These end bearings are up out of the sand so spillage does not affect them. The discs supporting the belt, being flexible, conform to the shape of irregular loads, reducing loss of material through spillage. The idlers clean themselves because constant flexing forces the sand from



NEW IDLERS consist of resilient neoprene discs permanently bonded to a flexible neoprene-sheathed steel cable which is suspended from a single sealed bearing at each end.

between the rotating discs. Neoprene was the natural choice for this use because of its lasting resilience and resistance to the abrasive action of the sand. After two years—more than eight times the service life of the steel idlers—the neoprene idlers are still on the job.

Specify neoprene in the rubber products you design. Of all general-purpose elastomers, only neoprene possesses a balanced combination of properties. For further information on designing new or improved products with neoprene clip and mail the coupon below.



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show how the Du Pont elas-
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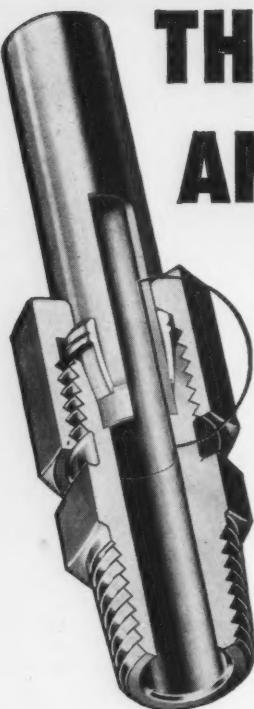
Du Pont Company of Canada Limited,
Chemicals Department, Room A-4,
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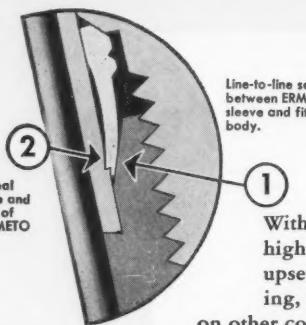


Specify Weatherhead "ERMETO"® for

LEAKPROOF CONNECTIONS THAT DEFY VIBRATION AND HIGH PRESSURE!



Line-to-line seal
between tube and
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Line-to-line seal
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body.

Faster Installation Trouble-free Service

With Weatherhead Ermeto you install high-pressure injection lines without upsetting tube ends . . . eliminate flaring, threading, welding or soldering on other connections. When the nut is tightened, the patent Ermeto sleeve shears a groove into the outside of the tube to form a positive seal that defies vibration and pressure. You can uncouple and reassemble the joint over and over. Weatherhead makes Ermeto in steel and stainless steel; hose assemblies with Ermeto ends are available on special order. Weatherhead also supplies tools to reseat any standard nozzle or pump for Ermeto connectors.

WHO USES ERMETO? All the leading organizations in a score of industries. They specify Weatherhead's Ermeto for their regular production, for defense work, in fact, for every application where they want to be sure of dependable connections.

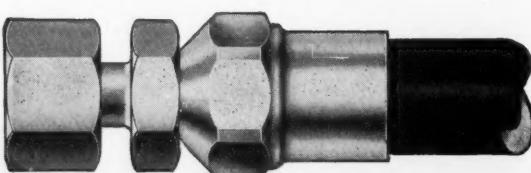


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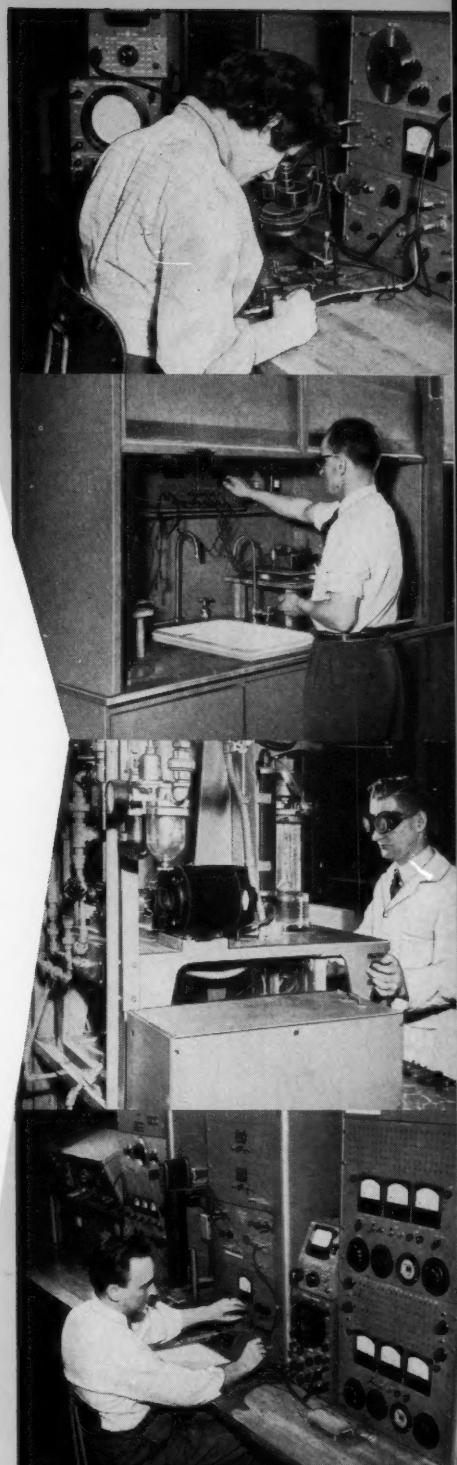
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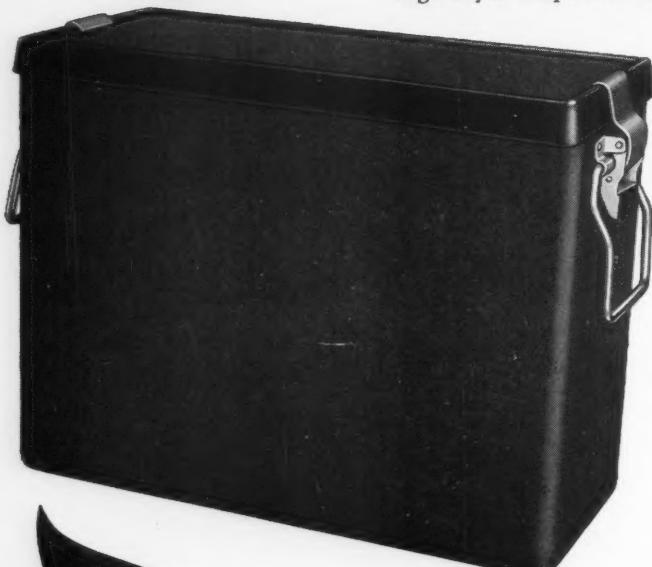
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C-G-E DESIGNED AMMUNITION BOX SOLVES PROBLEM

Re-use Feature Saves Money for RCAF...

This unique ammunition box below is just another example of G-E Polyester Moldings at work... solving problems and saving money. This moisture-proof, explosives container can be stored outside... can be opened regularly for inspection and *re-sealed* with no adverse effect. The container is lightweight, easy to handle, strong, durable, and proved superior to other materials. RCAF ordnance was handicapped by the lack of these advantages in previous containers.



The applications of G-E Polyester Moldings are many and varied. Every day new uses are discovered for this versatile plastic, uses that create new products and new markets. For instance—Polyester Moldings could be used in a wide range of products, from lawn furniture to luggage, from safety helmets to wheelbarrows. Polyester Moldings resist chemical action and are available in every colour of the rainbow.

Perhaps such versatility could give your product a helping hand. Many times low-cost Polyester Resins have added new life to an old product, have duplicated the favourable characteristics of materials formerly used at worthwhile cost savings.

For further information—contact the Plastic Advisory Service, Canadian General Electric Company Limited, Cobourg, Ontario.



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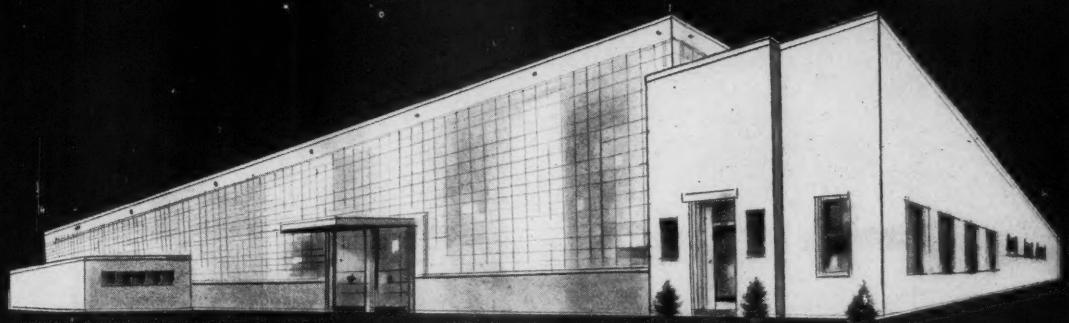
Wins Industry Awards!

This Ammunition Box won First Award in its Division in the 1956 Canadian Plastics Achievements Competition and won top honours in the 1956 Canadian Industrial Container Competition sponsored by Packaging Association of Canada.

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**Improved fastening methods created and developed
by completely integrated Canadian company**

"Imagination is given the reins" at the Hamilton plant of Dominion Fasteners Limited.

Here, through a combination of up-to-date facilities and creative personnel, this Canadian company is constantly inventing, developing and producing better fastening methods for industry.

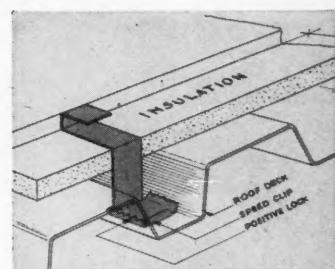
Manufacturers of the famous line of SPEED NUT brand spring tension fasteners, Dominion Fasteners Limited are always ready and able to provide any industry with an efficient and economical solution to any attachment problem.

**here's an example of how
the construction industry profits . . .**



Working with ROBERTSON-IRWIN LIMITED, a major supplier of steel roof deck to the Canadian construction industry, Dominion Fasteners Limited created and developed a new type SPEED CLIP for the attachment of insulation to roof deck. The precarious fire hazard associated with former methods was completely eliminated . . . as well as many other installation problems.

Designed and developed entirely in Canada by Canadians, this new addition to the SPEED NUT family of over 6000 types and sizes of fasteners is now being adopted in the U.S.A.



Robertson-Irwin Q-Deck mechanical insulation fastening method

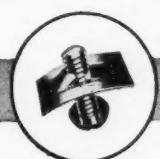
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FASTEAST THING IN FASTENINGS®

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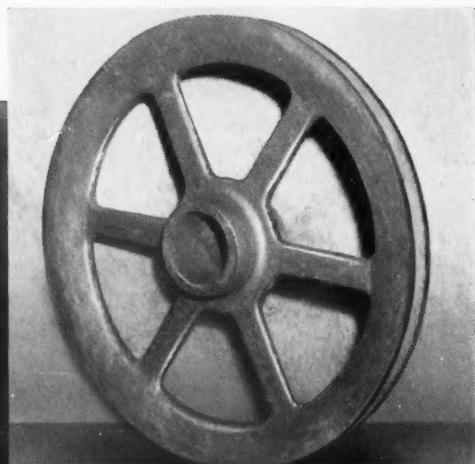
DOMINION FASTENERS LIMITED - Hamilton, Ontario
a Geo. A. Tinnerman corporation

New Design Applications of Ductile Iron based on its Many Advantages

Ductile irons are a group of cast metals which combine the processing advantages of cast iron with many of the engineering advantages of steel. This is a result of a low melting point, good fluidity and castability and high machinability plus a useful combination of strength, toughness, ductility and wear resistance.

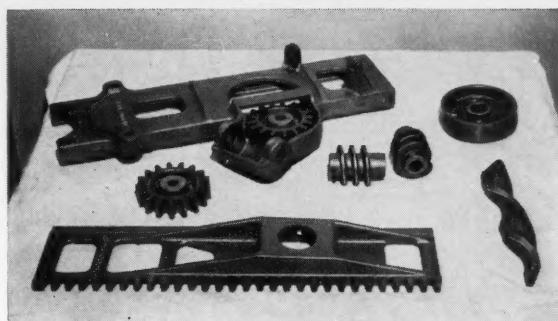
Ductile iron permits the production of castings which are intricately shaped or have very light sections and yet must withstand severe service conditions.

Ductile iron castings are not subject to size limitations. They are produced commercially in weights varying from 2 ounces to 100,000 lbs. with section thickness varying from 0.10" to 48".



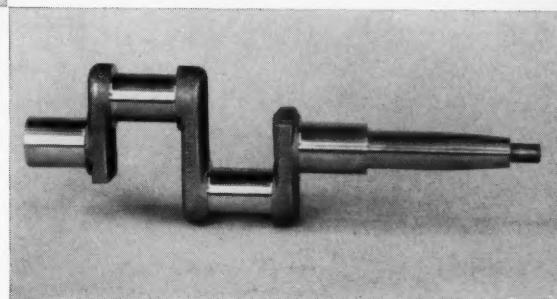
▲
Wheel of ductile iron 80-60-03 type.
Part of the suspension and running
gear of the famous Spanish-American
Cable Car that spans the gorge at
Niagara Falls, Ont. Supplied by Wel-
land Iron & Brass Limited, Welland, Ont.

◀
Ductile iron 100" pitch diameter gear of
the 86-60-03 type produced by Letson &
Burpee Ltd., Vancouver, B.C.



A good example of the intricate castings possible with ductile iron. These 60-45-10 type were cast by Bell Foundry Co. Ltd., St. James, Manitoba, to be used on a grain swather. Notice flat bar test piece, at right, twisted in ductility test.

A sample of an exacting casting that must be able to absorb shock, possess torsional rigidity, have excellent wear resistance and yet be readily machinable. This ductile iron crankshaft of 80-60-03 type was cast by Canada Iron Foundries, Limited, Special Products Plant, Hamilton, Ont.

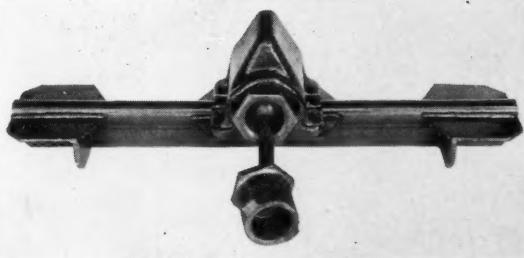


Ductile Irons Prove Economy Both in First and Overall Cost

Ductile iron castings are not expensive even in the first cost. But, more important, parts made of ductile iron have proved, in many cases, extremely economical in overall or ultimate cost. The superior properties of ductile iron have enabled castings to replace more costly forgings or welded structures. Their good machinability has effected important savings in machine shop time and labour. Their resistance to wear, shock or elevated temperature frequently permits their replacement of more costly materials and enables them to perform satisfactorily for a longer time.



**THE INTERNATIONAL NICKEL COMPANY
OF CANADA, LIMITED**
25 King St. W., Toronto, Ontario



▲
Ductile iron Jungle Trac, a type of equipment which adapts tandem axle trucks to half track for off-the-road service. Parts include adjustable links or "dumbbells", and bushings which were cast by Otaco Limited, Orillia, Ontario, in their 60-45-10 Ductalloy.

**THE INTERNATIONAL NICKEL COMPANY
OF CANADA, LIMITED,
25 King St. W., Toronto, Ontario.**

Please send me a copy of "Ductile Iron—The Cast Iron That Can Be Bent", which illustrates many applications and properties of ductile iron.

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Experience is the "hidden plus" that is built into every Torrington air-impeller design...experience derived from the development of literally thousands of design variations created to meet the performance requirements of products valued at nearly four billion dollars a year!

Typical of Torrington's product range in immediately available production equipment:

P SERIES: A high-performance fan blade designed for a wide variety of medium pressure applications.

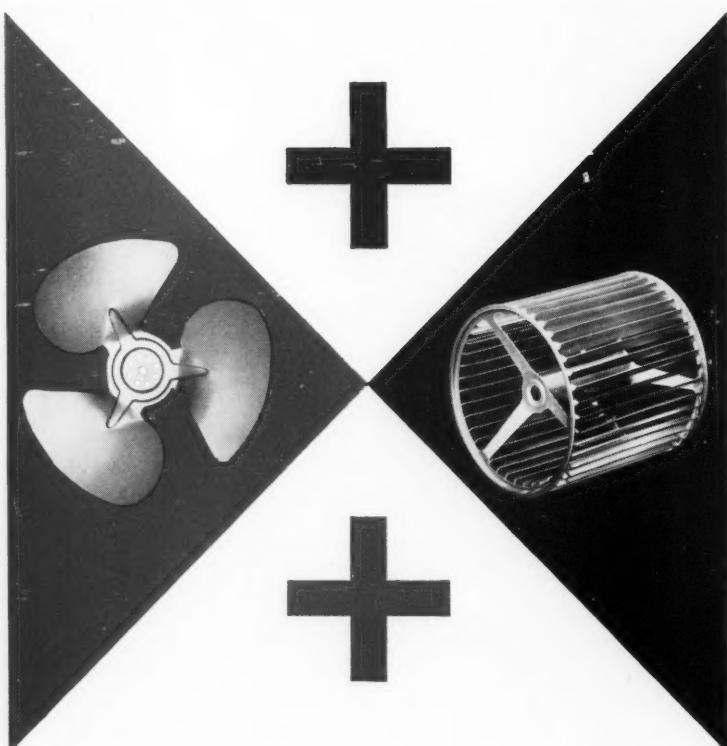
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People

Important people who are in the news

RECENTLY APPOINTED sales manager for the Montreal and Toronto districts for plastics molding compounds, including urea, melamine, alkyd and nylon, marketed in Canada under the Plaskon name, is George H. Martin.

Engineer Martin, who will be headquartered in Toronto, graduated with a BSc degree in Chemical Engineering from Queen's University, Kingston. He served



GEORGE H. MARTIN
Plaskon chemical engineer

from 1942 to 1946 in the RCEME, spending three years overseas, with the rank of captain. From 1946 to 1952 he was employed by Canadian Industries Limited as a sales engineer in the plastics division, during which period C-I-L was the Canadian representative for Plaskon products.

He is a member of the Society of the Plastics Industry, the Society of Plastics Engineers and the Quebec Rubber and Plastics Group.

Optimism is not enough

TECHNOLOGICAL DEVELOPMENTS in welding have come along so fast that industry is lagging far behind in applying the new methods, Joseph H. Humberstone, president of the American Welding Society, told members at the society's annual meeting at the Hotel Statler recently.

"From a repair and maintenance implement, welding has been transformed, in a remarkably short period, into a primary tool of fabrication, used where no other fastening process is as effective or even applicable. Acceptance of weld-

ing as a primary tool, however, has not followed with the same rapidity the many advancements that have been made in the method itself. In too many cases, in actual practice, welding is still employed as a secondary or supplementary fabrication tool," declared Mr. Humberstone, who is also president of Air Reduction Sales, Inc., New York.

Acknowledging that welding has achieved a position of eminence in the industrial world that we have never before enjoyed, he asserted that less than half of what should be welded today is being welded. Where welding could (and should) be doing the job more quickly, efficiently and economically, outmoded fastening methods are still being employed in the fabrication of too many products.

He called for a two-point program to bring the advantages of welding to industry. "Simplification of codes and specifications," he said, "is essential. A good engineer calls for the minimum of controls that will accomplish the desired result. I am afraid that at times we may be guilty of attempting to display our broad knowledge of the subject by calling for procedures far more complex than necessary.

"The second part of the program must be education," he said. "Very few engineers leaving college this year will have received a satisfactory introduction to the fundamentals of welding and its attendant processes. Very few will have ever seen a welding procedure specification or welding code. They will have no knowledge of the vocabulary of the welding industry. On the other hand, all will have had problems to solve involving the riveted joint. Under such circumstances, isn't it quite logical that their contact with a welding problem will leave them more or less in a state of shock when it becomes evident that there is much more to it than merely saying 'Weld here or weld there'."

Engineers appointed

TWO APPOINTMENTS in the Canadian Westinghouse Company's newly formed Defence Apparatus Division have been announced.

R. D. Graham has been named manager of the sales department and E. H. Dowell manager of the manufacturing department.

A 1949 engineering graduate of the University of Toronto, Graham joined

Canadian Westinghouse the same year and has held various sales positions. His last post was as assistant sales manager for the industrial products division. He has been associated with the company's naval apparatus program since its beginning and received his M Comm from the University of Toronto in 1953.

Dowell graduated from Dalhousie University with a BSc degree in 1941 and from the Nova Scotia Technical College, BE (Mech) in 1943 and joined Canadian Westinghouse in 1951. He has been engaged on steam turbine production as a manufacturing engineer, superintendent and (since 1953) as manager of manufacturing.

Warnock Hersey appointment

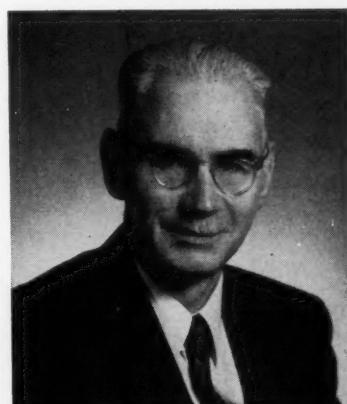
AN ANNOUNCEMENT HAS been made, by the Warnock Hersey Company Ltd., that A. J. Pluhar, BASc, MASc, PEng, is now manager of the non-destructive testing division, with headquarters in Toronto.

He received a degree in civil engineering from the University of Prague.

V.P. engineering

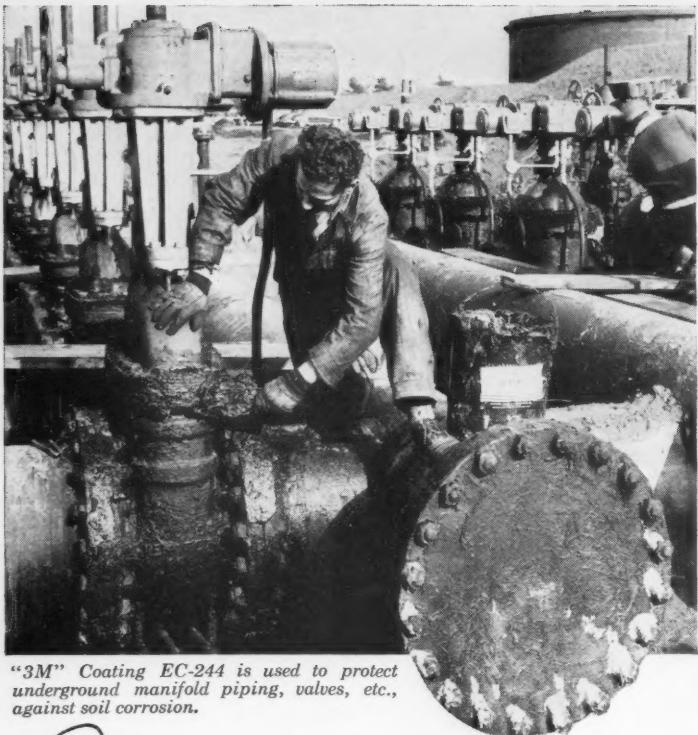
RECENTLY ELECTED vice-president in charge of engineering of Sangamo Co. Ltd., is Mr. G. G. Waite, formerly their chief engineer.

Electrical engineer Waite graduated from the University of Toronto in 1924



G. G. WAITE
Engineering V.P. at Sangamo

and then joined Westinghouse Electric and Manufacturing Co. at East Pittsburgh. After completing graduate student and engineering courses, he worked in supply engineering on special metering devices and later joined Sangamo, in November 1927. He is a member of the Association of Professional Engineers of Ontario, The American Institute of Electrical Engineers and the Institution of Electrical Engineers (Great Britain).



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"3M" Sealers are widely used in the aircraft and automotive industries.

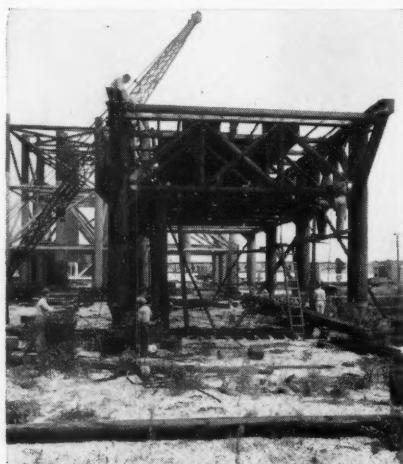


"3M" Adhesive EC-770 being applied to the inside edges of hot air register for bonding a felt strip gasket.

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Applying "3M" vinyl protective coating to a part of an offshore drilling rig.



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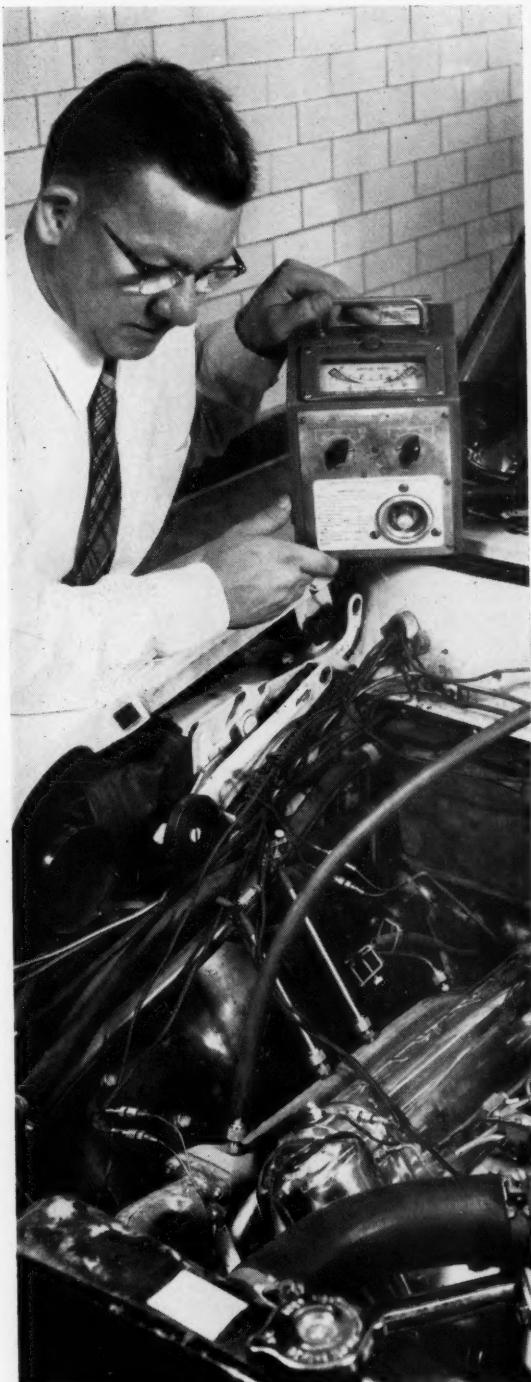


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Design Engineering



Engineer checks car engine for uniformity of fuel distribution by means of an exhaust gas analyzer.

When will fuel-injection really be ready?

Ready or no, carburetor-less cars are just around the corner and likely to appear early next year.

By Elliott Street

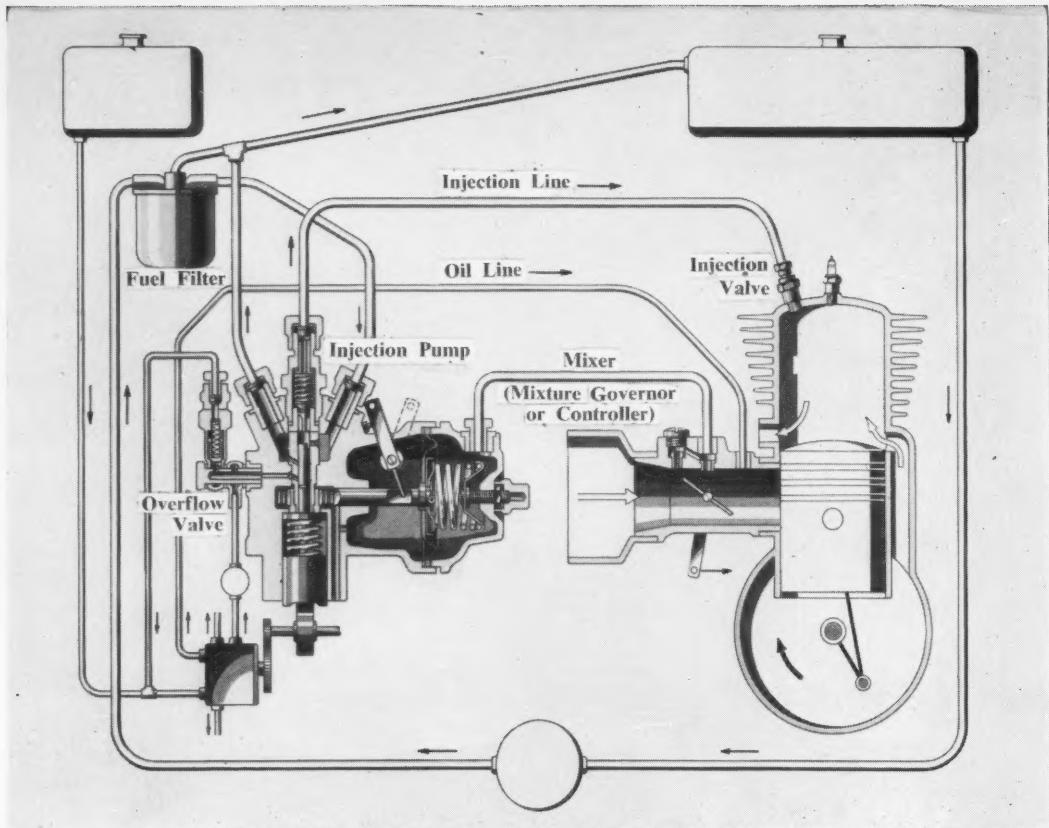
Fuel injection will probably appear for the first time on mass-production gasoline automobiles next year, despite indications that it has not yet been perfected. Manufacturers admit that there are still design problems to be solved, but some intend to come out now with the systems they have and worry about improving them later. They point out that this was done with automatic transmissions and it worked out all right!

The big question among fuel system designers is: which of the many fuel injection systems already designed, or still on the drawing board, will turn out the best. Undoubtedly, different systems will be required for different applications.

Before describing the various existing systems, it is interesting to know why, after so many years, the automobile industry has suddenly decided to push fuel injection.

Fuel injection for gasoline engines is not new. As far back as 1903, the Wright brothers injected gasoline into the intake manifold of their aircraft engine. Since World War II, fuel injection has been standard equipment in some aircraft piston engines. For years many diesel engine manufacturers have been trying to adapt diesel fuel systems to handle gasoline economically. In recent years, European racing and sports cars have used gasoline fuel injection, with good results generally. But despite its obvious advantages and its ability to improve engine performance, fuel injection equipment has cost too much to be widely adopted.

Recently, new designs and manufacturing methods have lowered the cost of some injection



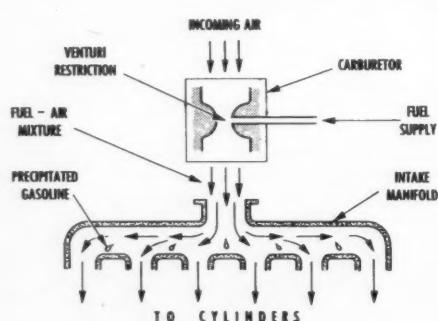
In the fuel injection system of Robert Bosch, Stuttgart, fuel is injected straight into the combustion chamber.

systems. At the same time, the demand for more and more engine power, requiring larger, more costly carburetors, reduced the cost gap between the two systems. Four-barrel carburetor systems, with air cleaners and fuel pump, now cost about \$50. Estimates are that an injection system can be mass-produced for about \$100. So the biggest deterrent is now diminishing.

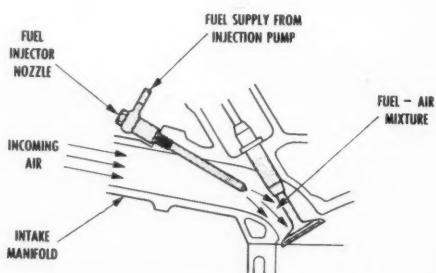
On the positive side, most automobile companies are anxious to have fuel injection as a new sales gimmick in the extremely competitive automobile business.

Automobile stylists favor it because, by doing away with the carburetor and repositioning the air cleaner, they can lower the hood and give the car a lower look.

Another important reason for not waiting any longer

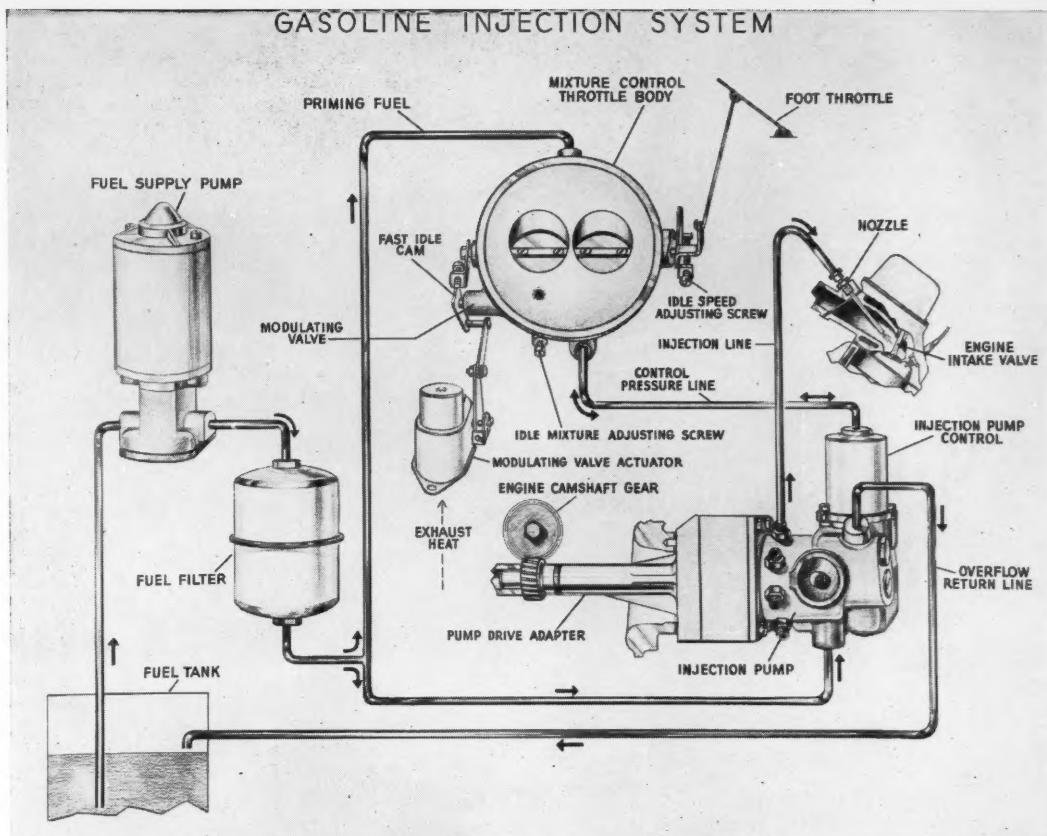


Typical Carburetion



Fuel Injection

Visual comparison of a typical carburetor system and fuel injection system in which the fuel is injected into the intake port. Alternatively, fuel can be injected directly into the combustion chamber



Schematic lay-out of the gasoline system used by American Bosch. Mixture control is based on manifold pressure.

for fuel injection is the awareness that the automobile gas turbine is coming. In five or 10 years, the gas turbine may make any major piston engine development comparatively unimportant.

So, with urgings from sales because of the threat of competition and the feeling that it is now or never, automobile manufacturers plan the early introduction of fuel injection. Rumor has it that Cadillac's "Eldorado" and Ford's "Thunderbird" will have fuel injection as optional equipment in 1957.

A fuel injection system is considerably more complicated than a carburetor system. It involves much more than the mere substitution of an injector pump for a carburetor. For instance, fuel can be metered by displacement pumps or distributor valves or by the use of an injection carburetor. The size of the fuel charge can be determined on the basis of manifold pressure and engine speed, or as a function of mass air flow. It can be supplied in timed, measured amounts, or in a continuous dribble through separate fuel lines to each cylinder, or through a common rail. The fuel can be injected directly into the combustion chamber, or into the intake port, or at some other point in the manifold.

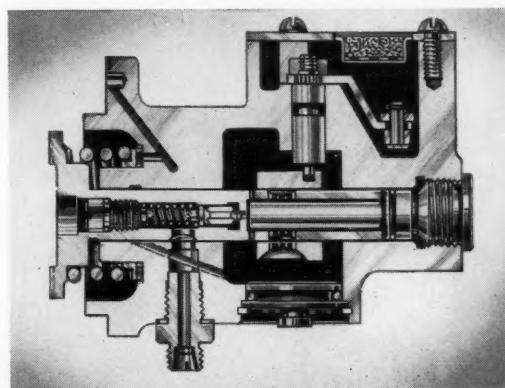
With so many basic design possibilities, it is easy to see why there are so many different fuel injection systems.

They may however be classified into three basic types: (1) timed injection, (2) continuous-flow injection and (3) injection carburetor systems.

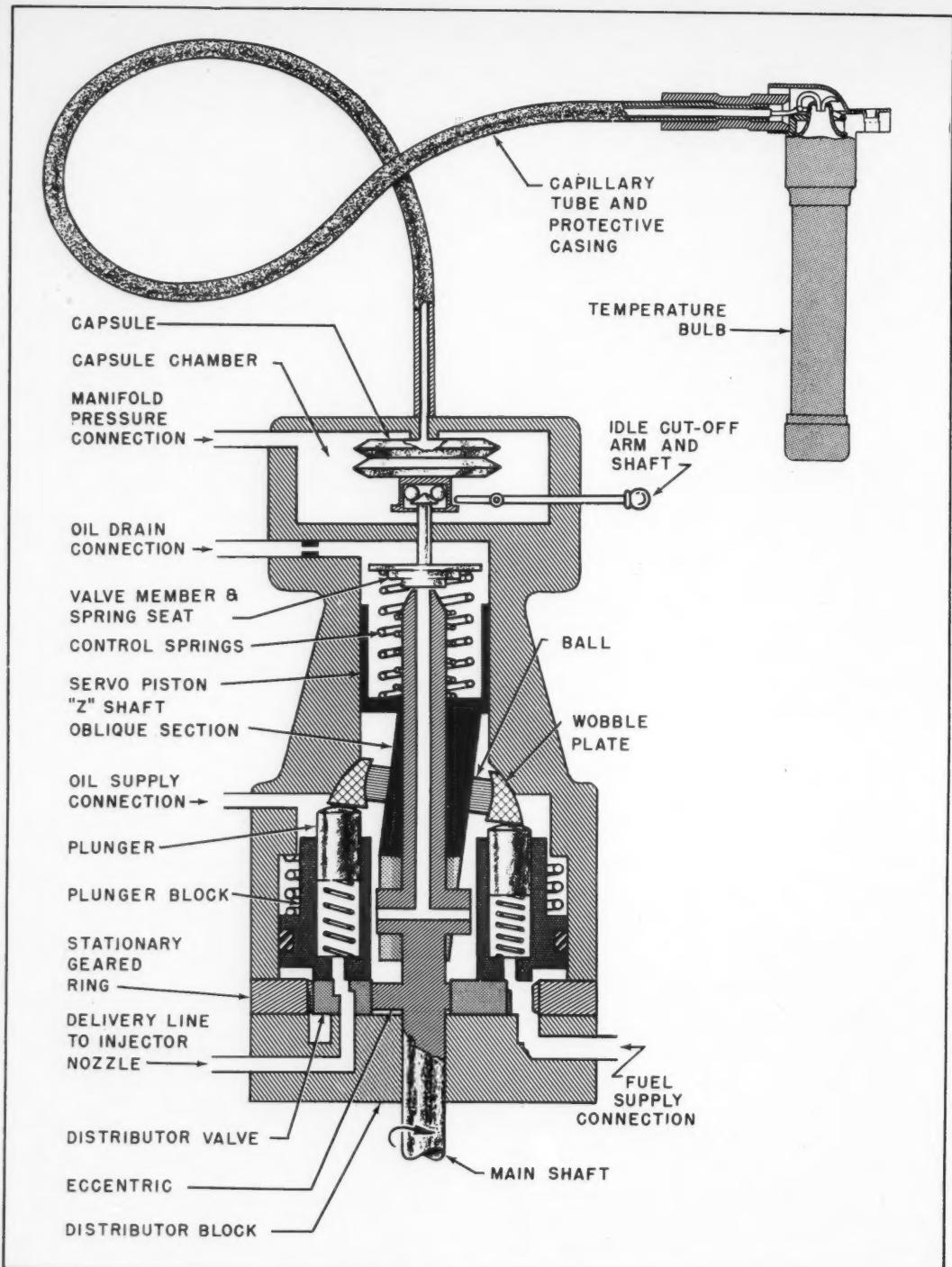
The timed injection system is similar to fuel injection systems used in diesel engines. Fuel is drawn from the

fuel supply tank, put under comparatively high pressure and metered by a multiple unit pump. It is fed in individual, timed charges along separate fuel lines to each cylinder and sprayed by nozzle directly into the combustion chamber, or into the intake port behind the intake valve.

In the timed injection system designed by Robert



Injection pump for the American Bosch system. Fuel is injected at the intake port through a spring - loaded nozzle at about 75 lb.



Simmonds Aerocessories plunger pump

The pump is of the variable stroke, axial type with the plungers arranged parallel to one another in a cylindrical plunger block. The plungers are actuated by a variable angle wobble-plate mechanism consisting of a hemispherical plate, the curved portion of which seats in a mating socket in the pump body casting. The flat face bears against the ends of the plungers and imparts the desired reciprocating motion. Through the centre of the wobble plate and its inner spherical ring passes a member called the Z shaft which is slidably mounted on the main shaft of the pump.

Bosch of Stuttgart, Germany, fuel is injected directly into the combustion chamber through a spring-loaded spray nozzle at about 100 lb. pressure. It is metered by an injection unit that has a constant stroke plunger for each engine cylinder. Plungers are rotated by a common rack which is controlled by a diaphragm that senses manifold pressure. Another sensing device corrects the control diaphragm and regulates the mixture for atmospheric pressure and temperature changes. An engine-driven pump delivers the fuel under pressure to the injection plungers. Excess fuel is returned to the fuel tank by a return line.

This is the system that is currently being used in the Mercedes 300 SL. It takes advantage of the cooling effect of the fuel spray on the piston and exhaust valves, and minimizes pre-ignition on the intake stroke.

In the American Bosch fuel injection system, fuel is injected at the intake port through a spring-loaded nozzle at about 75 lb.

The injection pump consists of an integral 8-lobe-face cam and a plunger. The plunger moves back and forth and rotates at half-crankshaft speed as a sleeve slides on it and meters the fuel. The fuel is distributed to each cylinder by the rotating action of the plunger. Mixture control is based on manifold pressure sensed across the throttle valves and passed to the metering sleeve.

Temperature and atmospheric pressure variations can be corrected for, too. The fuel supply pump is driven from the ignition distributor drive shaft.

This system was designed especially for gasoline engines and has been field-tested for over a year on standard automobile engines. E. I. Du Pont de Nemours & Co., in its experiments on fuel injection, has been using a modified American Bosch system.

Other timed injection systems

Simmonds Aerocessories, Inc., has a multiple point, low-pressure, timed, speed-density injection system for gasoline automobiles. Fuel is metered by a multicylinder wobble plate pump. Four plungers in separate cylinders act both as pumps and as metering devices. The wobble plate angle varies the plunger strokes from zero to maximum, depending on the motion of a Z shaft. A nitrogen capsule, which measures manifold pressure and compensates for temperature variations, operates a control valve in an oil fed servo-mechanism. This, in turn, positions the Z shaft for the required wobble plate angle, and consequently the flow of fuel.

Fuel at 20 lb. pressure is pumped to the plungers which feed it to a rotating distributor valve, thence to each cylinder. A spring-loaded nozzle injects fuel into the intake port at about 115 lb. Excess fuel is returned to the fuel tank.

The Simmonds system has been used on engines from 100 to 600 hp. A large system has been designed for higher horsepower engines. First used in the Rolls Royce V-12 aircraft engine during World War II, it is now used, with some changes, in United States Ordnance tanks. A modified system is available for passenger cars.

High-pressure, timed injection systems using positive displacement pumps are usually quite expensive to make, because the components must be designed and manufactured very accurately. For example, a slight variation in the length of the injection pump plunger strokes will cause a large difference in the amount of

fuel delivered to each combustion chamber. In addition, if the plunger cylinder is more than about 100 millionths out-of-round (or straight), leakage is possible or friction will cause the plunger to expand and jam.

Another problem is fuel line inertia. At high speeds, when the intake port is closed off, a sudden pressure wave may surge along the line, leaving a vacuum behind it. More fuel goes out of the line than is pumped in. The next charge from the pump is then partly used to refill the line, so there is a periodic variation in the size of fuel charge sent to the same cylinder. This cycling tendency gets worse as the engine speed is increased and fuel line pressures are lowered.

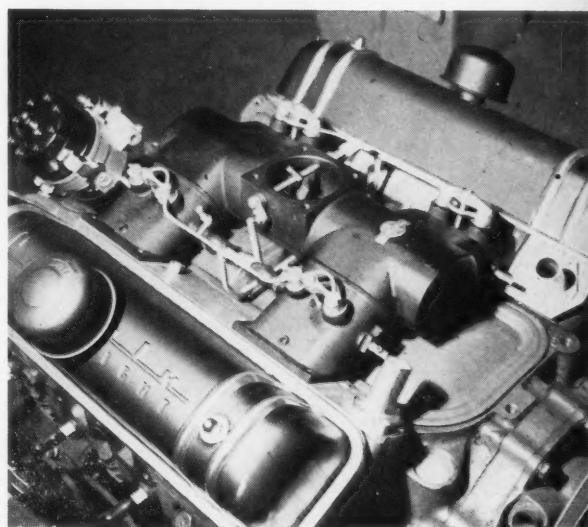
Instead of using an injection pump to meter the fuel, as well as to supply pressure for atomization, some expense can be saved by using a non-metering pump, a pressure regulator, and some sort of timed distributor device to meter the fuel into the intake ports. In the pump-distributor valve system, fuel is put under constant pressure by a non-metering displacement pump and then metered and timed to the individual cylinder valves by means of a distributor valve. This system is usually less expensive to make, because the number of accurate fits is less, and a costly component — a metering pump — is eliminated.

Since the spray nozzle settings will vary, the big problem with this system is to divide the fuel charge accurately. If the pressure of the fuel at the supply side of the distributing valve is made high enough, a variation of a few psi on the downstream side will not affect the flow very much. At high speeds, however, there is limited force available to accelerate the line charge at the start of the delivery. What is more, this type of system is very sensitive to variation in line area, elasticity or length.

In the Joseph Lucas Ltd., of Birmingham, England system, fuel is injected into the intake port by a spring-loaded nozzle with a cut-off pressure of 75 lb.

The injection unit consists of a rotating hollow

(Continued on page 64)



Continuous flow system

Details of installation of Fuelcharger Corporation fuel injection system. Shown are details of the air control, nozzle location and tubing harness for this system.

More economy with metal stampings

Take advantage of tool-makers experience by making slight modifications to the shape, size, dimensions or construction without altering the function

By Federico Strasser

It is an established fact that, in the design of metal stampings, close collaboration between the product or component designer and the tool engineer, toolmaker or press-shop foreman is always beneficial and profitable. It is usually possible to take advantage of the toolmaker's (or the tool-designer's) experience, in order to obtain certain advantages by means of slight modifications in the shape, size, dimensions or construction of a component, with respect to the preliminary design. Of course, the modifications must not affect the correct function of the component or part.

The object of the modifications can be one or more of the following: savings in raw material (stock); reduction of labor costs; reduction in the time of construction or cost of tooling; avoiding of difficulties and problems in the construction and maintenance of the corresponding dies; increase in the production rate; increase in the accuracy of the products; better use of existing production facilities and equipment; possibility of employing standardized stock; and possibility of using existing tooling (universal type dies).

Here follow a few cases of intelligent collaboration between the designer and the press-working people, cases taken from actual practice and grouped according to the similarity of their characteristics.

The simplest—and most frequent—example consists of not rounding the corners of rectangular workpieces or parallelograms. Then, instead of regular blanking dies (with or without combinations of previous punching operations) simple shearing dies can be employed with a stock utilization factor of almost 100% (fig. 1).

Whenever possible, eliminate small portions of the blank contour which protrude at the top, bottom or sides of the strip or sheet, portions which are not essential to the function (or strength) of the component. By cutting the endpoints of the workpieces, considerable savings in stock can be effected and the corresponding dies may even become cheaper. By doing this to the component of fig. 2, the whole necessity of dies has been eliminated. In fact, now the components are simply cut with squaring dies.

By changing the blank-end-form from rectangular to half-round (fig. 3), notable savings can be realized. In the present case, the stock economy was about 15%.

An interesting case is presented in figs. 4 and 5. Here the widths of the fingers "a" and the canals "b" have been slightly changed so that they became equal ("c"). Consequently, the component can be produced with an

almost scrapless strip-layout, with a stock saving of about 30% with respect to the original layout.

Fig. 6 shows how interesting advantages are obtained by slight modifications to the blank contour. Tool costs are reduced (more than 30% saving) and at the same time the component becomes stronger. By the way, the stock employed for the new component is the same as in the original design; the area increase comes from the scrap, which in the second case is less.

In many stamped components, the chief detail is the size and relative location of the holes; the shape and contour of the blank is immaterial. For example, in the case of the workpiece in figs. 7 and 8, the stock utilization factor was increased about 40% when the original design of fig. 7 was improved by the design of fig. 8. This was by means of a radical change in the external blank shape but conserving the relative position of the three small holes.

Use formed workpieces

Formed workpieces (bent, drawn and so on) offer excellent opportunities for obtaining great advantages through modification.

In bent workpieces, an important detail which must be mentioned especially is the convenience of maintaining the sides of the original, flat blanks—destined for further bending operations—straight (fig. 9 shows the flat blank and fig. 10 the bent workpiece). In this way, the flat blanks can be produced with squaring shears (see also the case of fig. 2) and thus is avoided the cost and time needed for the construction of the blanking dies, which would be necessary with other shapes.

In certain cases, the manufacturing process may be changed and thus great savings in material and tooling may be effected. For example, the hinge-like workpiece of fig. 11 has been redesigned according to fig. 12. In this way, the difficult (and therefore expensive) curling operation has been changed to the simple (and inexpensive) bending operation, with notable savings in tooling time and labor.

When box-like components must be designed, remember always that bending is cheaper than drawing. Take into account also that straight shearing is cheaper than corner-trimming. Of course, the appearance of the boxes is in inverted order (best are drawn boxes, least pleasant are boxes with sheared corners). In addition, the strength of drawn boxes is much greater than that of simply bent boxes. **(Continued on page 72)**

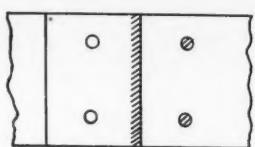


Fig. 1. Simple shearing dies can be employed with a stock utilization factor of almost 100%.

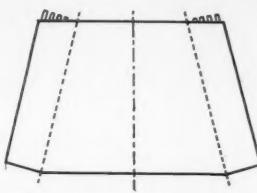


Fig. 2 Where possible, eliminate small portions of the blank contour which protrude, as shown.

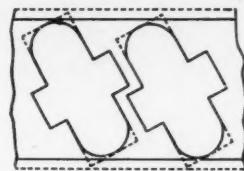


Fig. 3 Make savings by changing the blank-end-form to half round from rectangular shape.

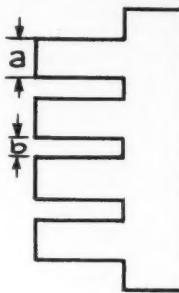


Fig. 4

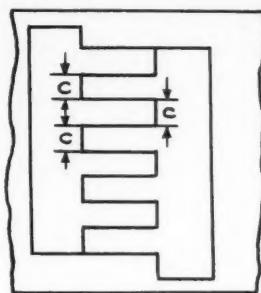


Fig. 5.

By changing the widths of the fingers "a" and channels "b" so that they equal "c," scrapless strip layout results.



Fig. 6. Shows interesting advantages attained by modifications to the contour.

Here are ways of saving on your metal stampings.

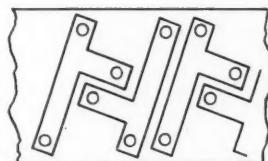


Fig. 7.

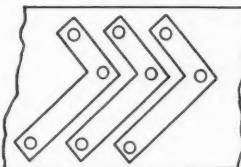


Fig. 8.



Fig. 9 Shows the flat blank used for producing the bent workpiece of Fig. 10, shown below.

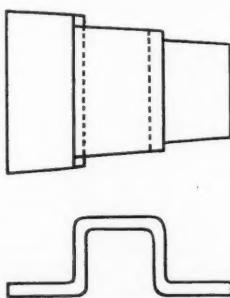


Fig. 10. The sides of the original, flat blank were kept straight in making this bent metal workpiece.

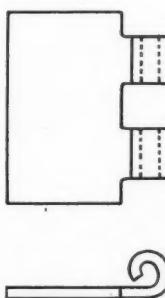


Fig. 11. Hinge-like workpiece before being redesigned to the form of Fig. 12.

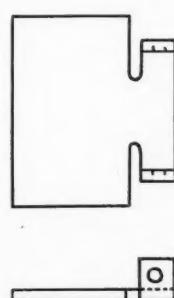


Fig. 12 By this redesign, the difficult curling operation has been eliminated.

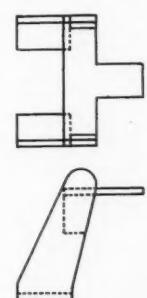


Fig. 13. Workpiece produced by the assembly of three quite simple parts.

Testing

Use this new electronic hardness rocker

Two methods for testing the hardness and drying time of coating materials

A testing device which is becoming increasingly popular as a means of determining the degree of hardness of paint films, is the Sward Rocker.

It consists of two 4 in. metal rings spaced an inch apart (see figure). In the lower half are two glass bubble tubes for visually indicating the start and finish of the test. A threaded rod extending from the top carries a bob for raising or lowering the centre of gravity; this regulates the frequency of oscillation. A rider on the nameplate aids in balancing the rocker.

It is important to have the test surface level. The panel or test piece must be held so that it does not move under the motion of the rocker and the rocker must be shielded from currents of air. To make it easy

to establish these conditions, a leveling table, a panel holder and a transparent cellulose shield unit are provided.

The leveling table is of nickel-plated brass, 7 in. by 12 in. by $\frac{1}{4}$ in. thick. A piece of bakelite $\frac{1}{8}$ in. thick is permanently bolted to form a top surface. The base plate is leveled by means of two adjusting screws. A polished plate glass is used for calibration of the rocker.

A cellulose shield unit prevents currents of air from influencing the rocker readings. The shield is attached to a base plate and may be raised or lowered over the rocker after it has been set in motion. Since the shield is transparent, the rocker oscillations may be seen.

A cyanamid panel holder is an additional accessory

A chemist testing the hardness of a paint film with the aid of this automatic counting electronic hardness tester.



which was originally designed by H. F. Payne of the American Cyanamid Company. It is essentially a small, ruggedly built screw press or clamp, designed for use with thin metal panels in order to eliminate slight curvatures. By inserting the panel and closing the press, the panel is held firmly for making hardness determinations. The holder will take panels up to a width of six inches.

To operate, the film is prepared on polished plate glass or on smooth sheet metal by any convenient method—doctor blade, spray gun, flow or dip. It is then air-dried or baked according to type. The panel is placed on the leveling table, or in the cyanamid panel holder and tested at 25°C. The rocker is calibrated at this temperature to avoid variation in the speed and size of the bubbles in the indicating tubes.

Further instructions for using the hardness tester are as follows:

Place the circular level provided on the test surface and adjust the leveling screws until the bubble in the level is centred. Swing the shield over the rocker, allowing a clearance of about $\frac{1}{2}$ in. so that the rocker can be manipulated, with the aid of a finger, a strip of flexible cardboard or a pencil. Set the rocker in motion so that the bubble in the left hand tube travels beyond the mark for three or four swings. Start the count when the bubble in the left hand tube fails to show beyond the mark. Remember to begin the count with naught (0). Remember also that it takes one swing to the left and one to the right to make one count. Stop the count when the bubble in the right-hand tube fails to travel beyond the mark in that tube.

Multiply the count by two, or add two successive determinations to get the rocker value. Shift the rocker to a new location for each test. Avoid specks or rough spots in the film. The rocker makes two tracks about $1\frac{1}{2}$ in. long, so there should be little trouble in finding test areas. A flashlight, or other small light, level with the bubble tubes and a few inches to the left of the rocker, helps the observer watch the bubbles. Keep the bearing edges of the rocker clean.

Clean the bearing edges of the rocker with a soft cloth or brush. Use water or other solvent if it seems to be needed. Keep the temperature at 25°C. Make a routine habit to brush off dust from bearing edges and surface before each test.

The automatic counter for the Sward hardness Rocker was developed by Imperial Chemical Industries, Ltd., for the close study of optimum oven temperatures and drying rates for synthetic and other paint formulation.

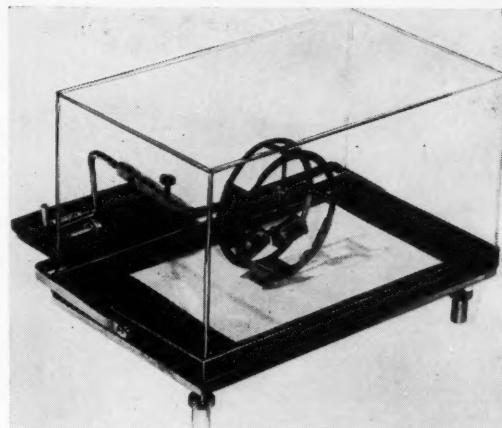
It is based upon the Sward hardness rocker, which has proved satisfactory in assessing hardness, if care is taken in its use.

This new electronic counting device eliminates disturbance by draughts, by panels not firmly anchored, by inattention to correct leveling and operator fatigue, whereby a spread is given to the counting, because the operator has noted incorrectly the start and stop positions of the rocker.

All the above points have been successfully controlled in the I.C.I. automatic hardness rocker, as all parts are enclosed for protection against draught; panels are clamped solidly between an upper and lower plate; the apparatus is fitted with level and leveling screws; and operator fatigue no longer applies, because counting is automatic and the rocks are recorded on an electric counter. Figure illustrates the complete instrument, which operates from a 110 volt, 60 cycle, AC outlet. Counting is automatic and takes place as the rocker oscillates, for the rocker is fitted with a shutter

which interrupts the light beam between the projector housing on the left side and the electronic counter on the right side.

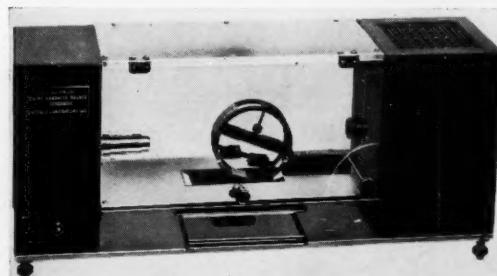
The test panel is clamped under the base plate by means of a spring-loaded table, which takes any size panel between four and 12 inches. The rocker is placed on this panel and rolled over to the right so that the rocker registers against a mechanical release device. The release is effected by turning a knurled knob in a clockwise direction. Provided the unit has been switched on and correctly leveled, it will count each rock until the amplitude of the rocker has fallen. *



Visual counting is carried out with this model C sward hardness rocker with levelling table and cover unit.

Hardness Readings for Various Materials

Material	Rate of Application (sq. ft. per gal.)	Hardness after 24 hours at 25°C. and 65% r.h.
Coach Finishing Varnish .	800	22
50-gal. Modified Phenolic Resin Varnish	800	47
Synthetic Resin Rubbing Varnish	800	84
Lead and Zinc House Paint	530	9
Alkyd House Paint	530	8
White Interior Paint	530	5
Flat Wall Paint	530	14
4-Hour Enamel	530	50



This is Model C hardness rocker for automatic counting. A shutter interrupts the light beam from the projector.

Mass produce with base plate method

To provide a rigid structure for keeping the parts in alignment, all rotating or moving parts are mounted on a single, previously made pillar or base

By William A. Dinges, HAMILTON WATCH CO.

Accuracy in precision mechanisms is largely a two part job. In the first place, it calls for precision moving parts. But equally important are accurately made structural parts for mounting the moving elements.

The watch manufacturing industry realized this generations ago and as a result has universally adopted the base plate method of construction. That is, all rotating or moving parts are mounted on a single, precisely made, "pillar" or base plate. A natural corollary of this principle of construction is the use of smaller partial or "sub" plates, also called "bridges," which help keep the parts mounted on the base plate in place, and which are themselves secured to the base plate. This method of construction provides a rigid structure that keeps the moving parts in accurate alignment and permits mass production of the precision base and sub plates. It also facilitates and permits flexibility in assembly.

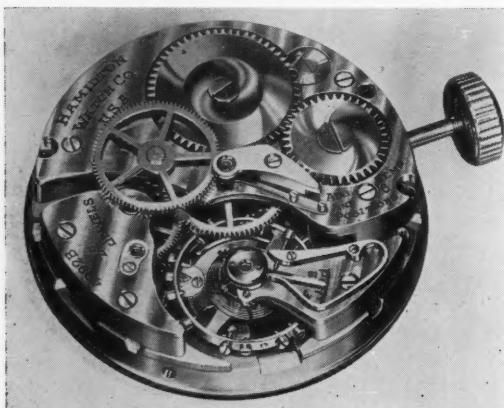
In this field — the manufacture of precision base plates for mounting the working parts of fine mecha-

nisms — the Hamilton Watch Co. has developed a specialized know-how which includes many special manufacturing methods and devices. A brief review of this accumulated know-how is presented below.

The defense program is creating a vast need for precise, complex instruments for aircraft and guided missiles. At the same time there is tremendous pressure to make these mechanisms ever smaller and more compact. To designers of such new mechanisms, the watch-making industry's solution to the problem of their mounting structures — the base plate method of construction — affords excellent possibilities for achieving greater miniaturization and easier mass production. In this review of advanced base plate production methods, many a designer of instrument components (such as gyros, synchros, meter movements and so on) or of complex instrument assemblies, will find a way to overcome his own miniaturization or mass production bottleneck.

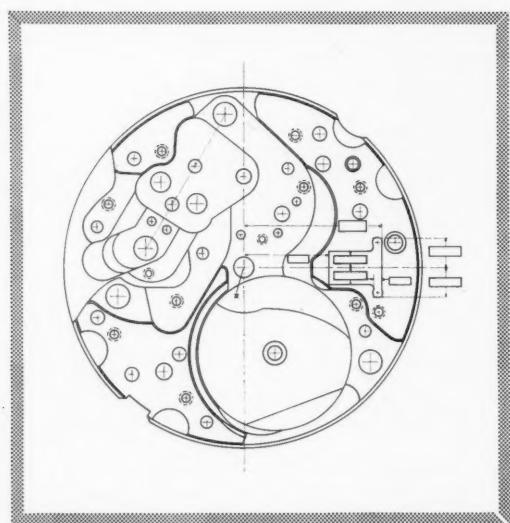
A grasp of Hamilton's advanced base plate production technique is best gained by taking an over-all glance at the whole process, noting its highlights.

Watches are universally constructed with a sturdy base plate as a foundation on which to assemble the



Above. Watch movement shows the foundation of accuracy in watches: the universal practice of mounting all operating parts on a single heavy pillar or base plate.

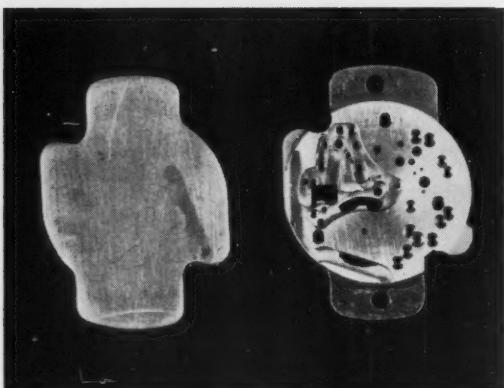
Right. Drawing of pillar plate (train side) for watch.





The Dixie co-ordinate locator

Location of spot centres of holes is checked with this high precision instrument. Spots are observed through the high power magnifying system while operator moves pillar plate (shown by arrow) along the rectangular co-ordinates.



Two stages in pillar making

Watch base plate is punched out of the metal blank, on left. Blank provides extensions for circular plate, on right. Precision holes in extensions position the plate.

Watch Base Plate continued

entire movement. Smaller sectional mounting plates, mounted parallel to the base plate, are used to permit easy assembly and to hold all the working parts properly in position on the pillar plate. Accuracy of alignment of gears, escapements and other interacting parts of the watch mechanism depends largely on accurate profiles and precise parallelism in the pillar or other mounting plates. It depends particularly on accurate location and precise dimensioning of the holes in those plates.

The plate producing procedure begins by making a blank for the plate by die-stamping it from sheet stock. The plates are then machined to produce accurately parallel faces. Then the blank is successively punched with carbide "shaving" dies, which first trim the blank to produce the precise profile required. Later punchings, with carbide shaving dies, enlarge holes in the plate to the exact diameter.

All carbide dies are of a standard form using car-

Get valuable ideas on machining techniques, tooling arrangements and inspection



Final inspection

Check on location of holes and recesses is made on this optical projector. Pillar plate is positioned, as shown by arrow. T-slot area of pillar plate shown on projector screen is magnified 20 times in this final inspection.

bide inserts pressed into a steel ring. Use of carbide dies prevents dimensional distortion which occurs when steel dies are heat treated for hardening. Also, die shaving permits production of many holes at once all of which are accurate in size and precisely located. Even holes as small as 0.019 in. diameter are produced by this die shaving process. A striking proof of the precision in hole size accuracy achieved by this die shaving technique is the fact that jewel bearings can be set directly into the mounting plates. No hand fitting of the jewel bearing into the mounting plate, and no special mountings, are needed to secure the jewel bearing in the plate.

Besides grinding to produce parallel faces and die shaving to produce accurate diameter of holes, two other highlights of the production process are largely responsible for the high precision of the base plates produced by it. These are: (1) the method used for dimensioning and locating, and (2) the inspection procedure used for quality control.

Instead of the conventional system of locating holes, recesses and so forth from finished surfaces, all dimensions are given from a single reference point Z in terms of distances along the two rectangular co-ordinate axes X and Y. This eliminates the pile up of machining errors due to the accumulation of tolerances.

Another important factor in eliminating errors in machining is the practice of making the base plate blank with attached tabs (also called lugs or ears). Accurate holes in these tabs permit precise location of the work for machining operations. When machining is completed, these tabs are removed. Note that the locating tabs are outside the base plate itself, so that if there is any inaccuracy present in the locating tabs, the error produced inside the plate is smaller. This principle helps substantially in holding machining operations to very close tolerances.

Practically every machining operation is immediately followed by an inspection operation to ensure that the job done is within tolerance limits. Inspection is often done by optical projection to check profiles and the location of slots, recesses, holes and so on. Also, extensive use is made of a Dixie machine or co-ordinate

locator, a high powered microscope through which the workpiece can be viewed while it is moved along either of the two co-ordinate axes by high precision, calibrated screws. But the bulk of inspection operations are performed by checking holes with unique go and no-go plug gauges designed and produced by Hamilton.

These plug gauges are often made of long wearing but hard-to-machine carbides, and the gauges are designed with the correct gauge diameter over their entire length, instead of tapering at the open end as conventional plug gauges do. This non-tapered end permits the accurate gauging of holes in thin plates, for which tapered end gauges give unreliable results. Also developed was a special size and form of handle for plug gauges in these extremely small sizes in order to provide better "feel" while gauging and to reduce gauge breakage.

These are the highlights of the mounting plate production process, as a result of which the plates produced are so accurate in dimensions, and the holes in the plates so accurate in diameter and so precisely located, that Hamilton can assemble watch movements by a standard, conveyor-line assembly procedure similar

to that in the automotive industry. That is, interchangeable parts arrive at proper points on the conveyor and are directly mounted on the pillar plate. Smaller (sectional) mounting plates are so accurate in profile, and the bearings in them so accurately located, that they assemble onto the pillar plate without hand fitting, and support the moving parts without binding or end play.

Altogether, the process involves about 150 machining, die punching and inspection operations and so requires careful planning.

It would seem that this is a very elaborate process merely for producing the mounting structure for a precision mechanism. It must be remembered, however, that mounted on this pillar plate are working parts which must be assembled in place, not by hand fitting, but by conveyor line assembly. And once assembled, these parts must be so accurately aligned that they can be driven for 24 hours by the fraction of a millionth of a horsepower output of the main spring. Also, the operation of the whole mechanism must be so precise that the maximum allowable loss or gain is only one second in 3,600 (that is, one second every hour). *

methods for solving miniaturization and mass production problems in instruments.



Operator inserts sub plate

Gear train of watch, already mounted on base plate, is held in place by sub plate, the use of which permits flexibility in assembly. When screwed accurately in place, the sub plates and pillar plate together form a rigid mounting.

Material

Use sintered aluminum pulver or SAP

Well-known in metallurgical circles, SAP is still something of a problem

By Tony Last, ONTARIO RESEARCH FOUNDATION

Three years after the end of World War II, when European industry was beginning to regain some semblance of order, there was published in Switzerland a paper which was to have a far reaching effect in the fields of high temperature alloys and powder metallurgy.

This paper brought into the public eye the work that was being performed by Aluminum Industrie Aktiengesellschaft (A.I.A.G.) on the pressing and sintering of aluminum powder with varying amounts of aluminum oxide. These aluminum sintered bodies were called SAP which is an abbreviation of "Sinter-Aluminum-Pulver."

Sintering processes are, in general, employed for the production of compacts from metals, oxides, silicates or organic materials in the form of powder. Powder metallurgy allows the production of high precision finished components; indeed, for some materials, it is the only method for producing a given shape. In this connection, the manufacture of sintered bodies from high melting point metals, such as tungsten and

molybdenum, or from mixtures of metal carbides or oxides, may be mentioned.

The new SAP product shows potentialities for use at temperatures of 800F, an increase of 400F over the best commercial high temperature aluminum alloy. It is produced by pressing aluminum powder of fine particle size into compacts under a pressure of 14 to 35 tons/sq in., sintering the compacts at temperatures of 450 to 600C, followed by hot pressing at 35 tons/sq in. and finally extruding into rods. These rods can be rolled into sheet or forged into sections and shapes.

Aluminum is not normally suitable for sintering, because of the presence of an adherent film of oxide which is very tough and chemically quite inert. The thickness of this film depends on three things: (1) the purity of the powder, (2) the strength of the oxidizing medium, and (3) the time and temperature of exposure to the oxidant. The exposure to air of commercial aluminum of 99.3 to 99.5% purity produces an oxide film about 0.01 micron thick (about one hundred thousandth of a millimeter).

The Swiss discovered, however, that contrary to popular belief, this film did not have a detrimental

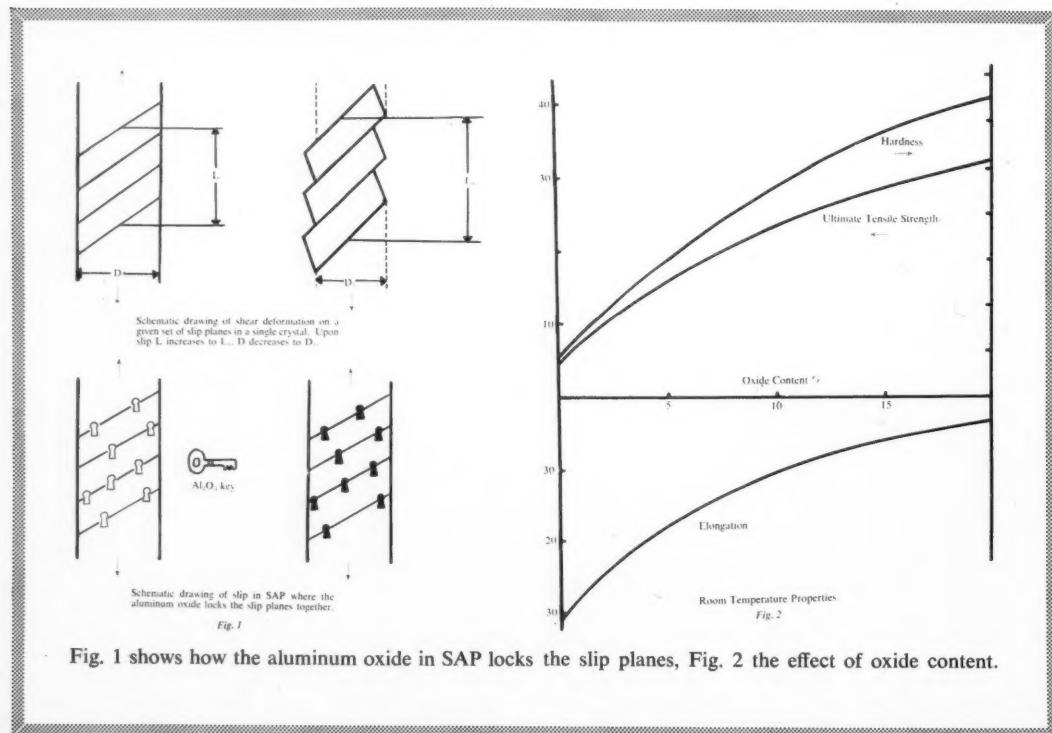
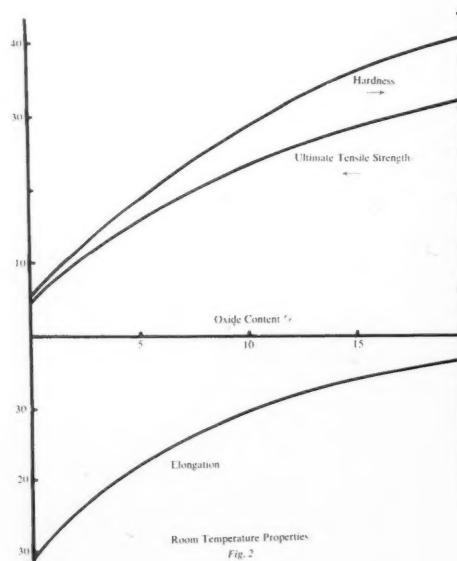


Fig. 1 shows how the aluminum oxide in SAP locks the slip planes, Fig. 2 the effect of oxide content.



effect on the physical properties of a compact at room temperature, apart from reducing the elongation, and gave amazing results at higher temperatures.

The properties of SAP compacts are dependent on the size, shape and surface area of the powder, as well as the oxide content. Aluminum powder can be made from the molten state by shotting or vigorous stirring in the pasty range or from the solid state by stamping or ball milling. The powder produced from the solid is infinitely better, since its shape is flaky and it is particularly good for producing the right oxide content and also good compacting. It has a particle size of 1 to 100 Angstroms (10^{-9} to 10^{-7} millimeters). Usually about 50% of the powder is below 2 Angstroms across the flake.

Aluminum foil or atomized powder of greater than 200 microns is used as a starting material and is comminuted by the Hametag process (a mechanical milling) or by a ball mill with an atmosphere kept continuously at about 8% oxygen. Stearic acid is added in order to lessen the risk of explosion, which is always present with exceedingly fine powders. It is interesting to note that the oxide layer on atomized powder is always crystalline (cubic) and brittle. On comminution, however, it distributes itself evenly over the particles. Flake powders at room temperature have an oxide layer which is amorphous, clear and ductile. As the particle size decreases, so the oxide content and the surface area increases. For example, assuming a 0.01 micron oxide thickness, the oxide content is about 20% for a particle of 0.1 micron thickness but about 2% for a particle of 1 micron thickness.

The influence of oxide content and particle size on the strength of SAP compacts at room temperature is shown on Fig. 2. This vast increase in tensile strength from the 5 tons/sq in. of pure aluminum to the 30 tons/sq in. of SAP with 20% Al_2O_3 is characteristic of this alloy.

The tensile strength of an aluminum-copper-magnesium alloy in its heat treated state is about 30 tons/sq. in. and after heating for one day at 400°C it drops to 7 tons/sq. in. As against this, SAP with approximately 10% oxide holds its strength at 20 tons/sq. in. after heating at 500°C for one month.

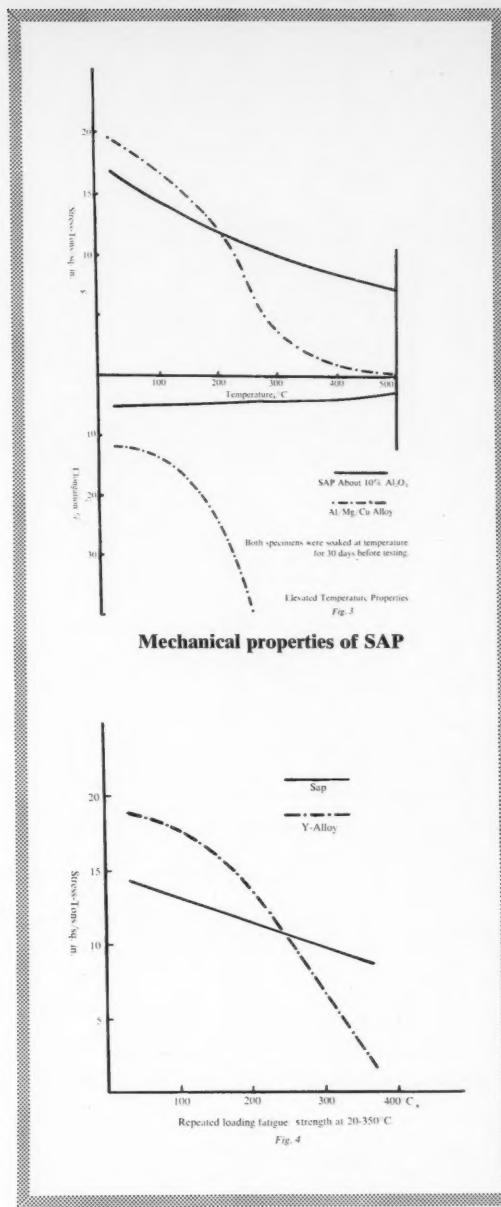
Comparing the above heat treatable alloy with SAP at elevated temperatures, the difference in tensile strength and elongation can readily be seen from Fig. 3.

The creep strength of SAP shows such a marked improvement over other aluminum alloys that in some cases it is impossible to measure the elongation of the alloys with loads acceptable to SAP, owing to the breakage of the alloy test pieces after a few hours under load.

To compare again with the aluminum-copper-magnesium alloy already mentioned, it would be safe to accept, in the case of SAP, a value of 6 tons/sq. in. as the creep strength at 250°C, whereas with the alloy a safe figure would be less than 4 tons/sq. in.

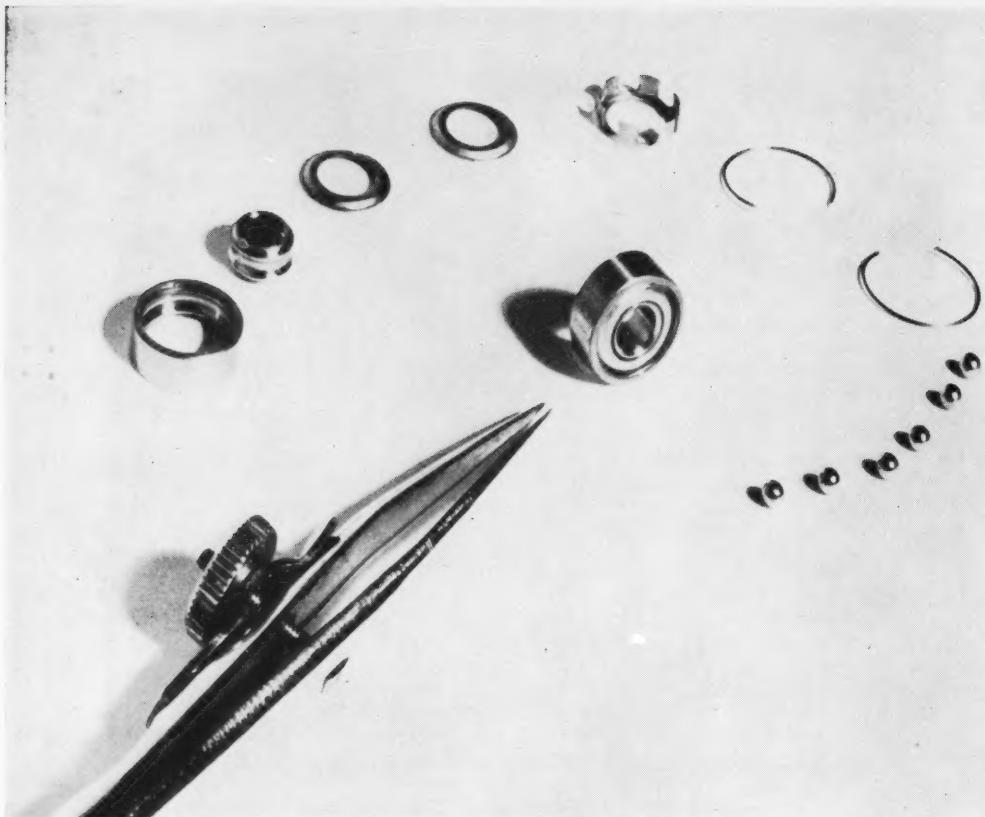
Fig. 4, compares the fatigue strength of SAP at 2×10^6 cycles and temperatures from 20 to 350°C with Y-alloy, which is notable for its high hot strength. The superiority of SAP above 300°C is apparent.

With this impressive list of properties and physical advantages, how can we use this super alloy? There are, of course, problems. The mechanical difficulties in the compaction stage are numerous; seizing or galling effects of the die walls are difficult to control and even the use of internal lubricants in the compacts often leads to pore generation and objectionable residues. The flow rates of aluminum powders are poor and lead to



extrusion between the moving and stationary parts of the dies. This can be controlled by ultra-efficient die wall lubrication, which can often be expensive. The size limitation of the compacts is about 6 in. maximum in the production process. The expense and lack of available material are other main troubles today.

Already, however, some of the problems have been overcome by good design. Small pistons have been made of SAP with success and it has been applied to flanges in combustion engines and turbine blades. So it remains now for the designers who have not hitherto considered aluminum in their products, owing to its poor high temperature properties, to take a greater interest in sintered aluminum powder and then, no doubt, the production problems will be solved and SAP will be in use as a light, high temperature alloy. *



How miniature the ball bearings really are is vividly portrayed by this comparison with a conventional drawing pen.

How to select miniature ball bearings

There is a growing need for them because of the present-day trend toward miniaturization in precision instruments and electronic devices

By R. H. Carter, MINIATURE PRECISION BEARINGS INC.

Increasing emphasis on the miniaturization of precision instruments and electronic devices has made the miniature ball bearing a familiar component to most design engineers. Capable of fulfilling exacting performance requirements, there are over 500 types and sizes of miniature ball bearing, ranging in size up to $\frac{3}{8}$ in. They take up little space and add practically no weight to completed assemblies.

The method of application of miniature ball bearings is similar to that for larger ball bearings. Their specification is usually based on these three operating requirements: low torque, both frictional and inertial; minimum space and weight; long life in comparison with load capacity, speed, wear, shock and vibration.

Having less mass and a shorter moment arm about their axis, miniature bearings have far less inertia than larger bearings, and miniature ball bearings have sub-

stantially lower frictional torque than sleeve, roller and needle bearings of equivalent size.

Space is usually a more critical factor than weight in the design of miniaturized assemblies, except in aircraft instruments, where even the smallest weight reduction is welcomed, although both are reduced by miniature ball bearings. These bearings usually allow the designer to reduce also the size and weight of associated shafts, housings, gears and so on.

For a given load and speed, the operating life of miniature ball bearings is less than that of a larger ball bearing but greater than that of jewel and air bearings. However, as assemblies decrease in size, load capacity usually becomes a less important criterion in bearing selection. Higher speeds often accompany miniaturization and make the higher speed capacity of miniature ball bearings (as compared to jewels, small roller and needle bearings) an important specification factor.

The precision of modern instruments makes bearing wear a more important problem than actual failure.

BEARING CONSTANT

C

500
400
300
200
150
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1

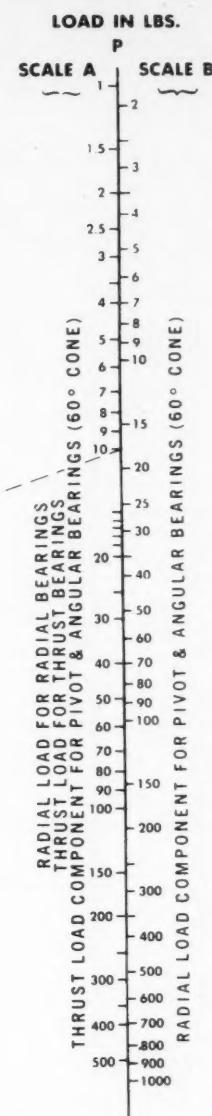
RPM

60,000
40,000
30,000
20,000
10,000
5,000
3,000
2,000
1,000
500
100
50
10
5
1
0.5
0.1
0.05
0.01
0.005
0.001
0.0005

L_N
MILLIONS
OF CYCLES

20,000
10,000
5,000
3,000
2,000
1,000
500
300
200
100
50
20
10
5
2
1

L_H
HOURS



PRACTICAL METHOD FOR FINDING BEARING LOAD OR LIFE

The nomograph gives the load and life of bearings of SAE 52100 steel. The load value obtained must be multiplied by 0.85 for bearings of stainless steel and by 0.25 for bearings of beryllium copper. In addition, when the outer race rotates while the inner race is stationary, the final value of load from the nomograph must be multiplied by 0.7.

To find the life in hours of a bearing whose C factor is 30, operating at 30,000 rpm under a 10 lb load, draw a line (1) from C=30 to P=10 (use scale A). Then from rpm=30,000 draw a second line (2) through the intersection of the first line and column L_N. Life, in hours of operation, is read where the second line intersects column L_H. In the example, L_H=15 hr.

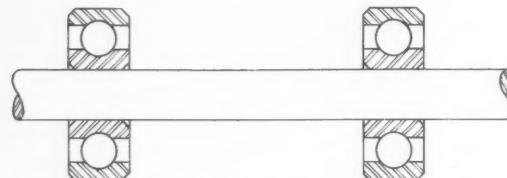
Miniature Bearings continued

Increased play, both radial and axial, caused by wear and resulting in excessive displacement of the rotating member during operation, cannot be tolerated in many applications.

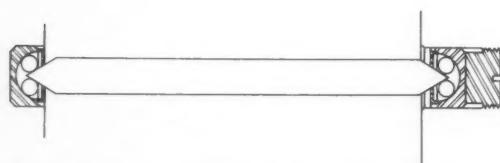
Standard ball bearings will withstand shock and vibration normally encountered. However, extreme shock and vibration can cause rapid failure rather than slow deterioration of performance characteristics. Miniature ball bearings are commonly selected to replace jewel bearings for shock and vibration resistance.

Although there are many types of miniature ball bearing, the most common are those given in Table 1. The size range represents minimum and maximum dimensions commercially available for a standard product.

SAE 52100 chrome-bearing steel is normally used because of its high tensile strength, hardenability and excellent wear resistance. However, miniature ball bearings are generally available in two other materials: stainless steel 440C, for corrosion resistance, and beryllium copper, for non-magnetic applications.

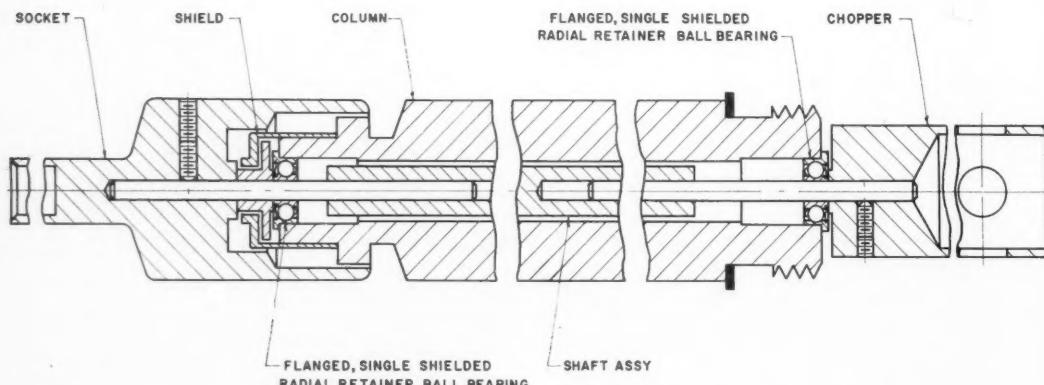


This diagram shows a shaft supported between two radial bearings, one of the three most common arrangements.



An alternative arrangement is to use pivot bearings at each end of the shaft, as shown diagrammatically here.

There are three common mounting arrangements for miniature ball bearings.



Still another method is to mount the shaft so that it is supported between flanged radial bearings, like this.

In many cases the critical factor in the specification of miniature ball bearings is the magnitude of frictional torque. Inertia may be important in intermittent operation, where the rotating member is constantly accelerating or decelerating, but more often starting torque or running frictional torque is the determining factor. Starting torque is, of course, that necessary to create movement, whilst running torque is that required to maintain rotation at constant speed.

Torque attributable to friction is influenced by: raceway finish and dimensional accuracy; ball finish and dimensional accuracy; internal bearing geometry; bearing material; ball retainer or separator material and design; lubrication; cleanliness; operating temperatures, if they affect internal clearances; type and magnitude of load.

Since most of these factors occur in the design and manufacture of ball bearings, they are controlled by the manufacturer. Only the four last factors are affected by operating conditions, but their importance is such that the design engineer must give them careful consideration in designing the bearing application. Cleanliness can be an extremely important factor in the use of miniature bearings, since very small fragments of dust or grit can adversely influence performance. Special attention to cleanliness in handling bearings will therefore do much to guarantee satisfactory operation.

The relationship between load, speed and operating life is expressed by the equation:

$$P = \frac{C}{\sqrt[3]{L_h \times rpm \times 60 \times 10^{-6}}}$$

Here, P is the radial load (lb), L_h is the average life (hr), rpm is the speed of the shaft and C is an empirical factor depending on over-all bearing design. Actual values of C are determined by the bearing manufacturer.

The nomograph shown is an extremely practical method for finding bearing load or life. It applies equally well to bearings carrying exclusively radial, exclusively axial (thrust) or combined loads.

The previous method of determining these criteria graphically required the use of a graph in which load was plotted against speed. An average life for the bear-

TABLE 1

No.	Type	Operating Conditions
1	Radial	High radial loads, moderate speeds, moderate thrust loads.
2	Thin-wall radial	Same as radial. Accommodates larger shafts while maintaining small OD.
3	Radial retainer	Low starting torque, moderate or medium speeds, moderate radial and thrust loads.
4	Shielded radial (single or double shields)	Protects bearing against foreign matter, retains lubricant. No increase in width.
5	Spring separator	Oscillating motion, low speeds (up to 100 rpm).
6	Shielded retainer	Same as shielded bearing, plus advantages of radial retainer. Slight increase in width.
7	Flanged radial	Convenience in mounting eliminates need for seat in housing or special retaining devices. Aids squareness in mounting, saves axial space in gear trains, axial positioning determined by flange width rather than machining operation.
8	Flanged radial retainer	Combines advantages of flange design with radial retainer.
9	Flanged shielded retainer (single or double shield)	Combines advantages of flanged, radial retainer, and shielded bearings.
10	High speed (available with vacuum impregnated retainer)	Adapted to very high speeds, combined radial and thrust loads. Mounted in opposition, bearings permit axial adjustment of internal bearing clearances.
11	Flanged high speed (available with vacuum impregnated retainer)	Combines advantages of flanged and high speed bearings
12	Angular contact	Receives combined loads on conical 60 deg pivot point. Self-contained.
13	Pivot (spherical seat or race types)	Designed for high loads, severe shock. Used with 60 deg pivot points. Shaft misalignment 4 deg for spherical types, 2 deg for race type.
14	Thrust	Heavy thrust loads, medium speed, minimum space.
15	Grooved radial	Designed to guide and provide support for moving wires, artificial filaments, or to position precision mechanism on a track.
16	Grooved radial retainer	Combines advantages of grooved radial and radial retainer bearings.
17	Shielded grooved radial retainer (double shielded)	Combines advantages of grooved radial bearing with those of shielded bearing.
18	Self-aligning design	For use where shaft misalignment is from 5 to 12 degrees. Accommodates moderate radial loads and minimum thrust loads.

The most common types of miniature ball bearing are listed here as a ready reference guide for the design engineer.

TABLE 2. Recommended Tolerances for Shaft Diameter and Housing Bore

Type of fit	Clearance	Interference
Shaft diameter	(B -0.0001) +0.0000 -0.0002	Bearing bore +0.0000 -0.0002
Resulting fit* Extreme Average	-0.0001 to +0.0003 +0.0001	-0.0002 to +0.0002 Line-to-line
Housing Bore	Bearing OD +0.0002 -0.0000	(OD -0.0002) +0.0002 -0.0000
Resulting fit* Average Extreme	+0.0004 to 0.0000 +0.0002	+0.0002 to -0.0002 Line-to-line

*Where corresponding bearing tolerance is +0.0000, -0.0002 in.

Miniature Bearings continued

ing was assumed in these graphs and a separate line plotted for each different bearing. The nomograph does not require the assumption of an arbitrary average life, and is at least accurate.

If load, life and speed requirements are fixed, the design engineer can determine the necessary constant (C) and select a bearing accordingly.

Of course, neither method of graphical solution will give accuracies to the nth degree, but the nomograph is sufficiently accurate for all practical purposes. For greater accuracy, the equation must be solved numerically.

A rule-of-thumb method allows thrust loads (in addition to radial loads) of half the actual load, without any adjustment of load rating. If thrust loads exceed a value equal to half the radial load, the bearing manufacturer should be consulted before proceeding with the design. A thrust bearing may be the solution to such a problem.

Choice of fit between bearing and shaft or housing depends upon the application. Tolerances must be set in recognition of bearing tolerances and application requirements. Recommended clearance and interference fits are given in Table 2.

In light load and low speed applications, and when relative axial movement between shaft and bore is necessary, shaft clearance fits are most appropriate. Relative movement between shaft and inner ring is necessary under some conditions of extreme operating temperature differentials, dissimilar materials and large distances between bearings. Clearance fits prevent possibly undesirable thrust loadings. Heavy loads with inner ring rotation, rapid oscillating motion or very high speeds usually call for interference fits at the shaft.

Where the shaft rotates, clearance fits are normally used on the housing bore. Such fits provide sufficiently tight housings while facilitating production assembly. When the housing rotates, housing interference fits are generally required to prevent the bearing from moving relative to the housing and wearing the softer housing material. If relative dimensions of shaft and bore, or housing and OD, are specially critical, selected bearings may be supplied from within the standard ABEC toler-

ance limits. Similar pre-selection of housings and shafts will enable the user to control fits when using selected bearings.

The total distance by which the outer ring of a bearing can be moved radially, when the inner ring is held fast, is known as radial clearance. Axial play is the total distance, on both sides of centre, by which the outer ring can be moved axially in relation to the inner ring. Ball diameters and race curvature determine the relationship between radial clearance and axial play.

Radial clearances ranging from 0.0002 to 0.0008 in. are usual for miniature ball bearings. However, smaller or larger radial clearances can be obtained. Since, to produce low frictional torque, some radial clearance is usually desirable, the standard minimum of 0.0002 in. is considered a practical compromise between torque and radial motion requirements. Negative radial clearance bearings are useful for applications calling for extreme rigidity, and are produced by preloading the bearing.

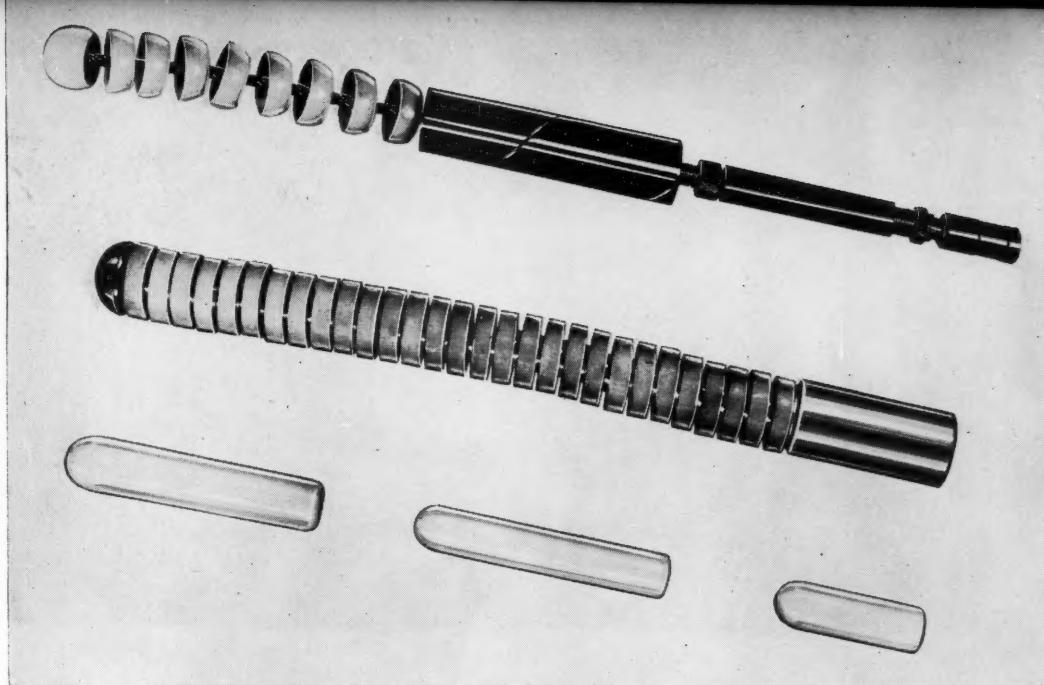
Change of radial clearance occurring between static and operating conditions presents a problem to the designer. Interference fits and differing thermal expansion coefficients which may change the amount of axial play will affect radial clearance. A reduction in radial clearance of 80% of nominal interference must be assumed to ensure positive radial clearance when using an interference fit at either housing or shaft.

Normal practice is to press fit the rotating member and allow a clearance fit of the non-rotating member to compensate for thermal expansion or contraction. However, radial clearance can sometimes be specified to permit a required axial play. Unless comparatively large interference or thermal motion along the axis is anticipated, the internal clearances provided in normal manufacture are sufficient.

The three most common mounting arrangements are: A. Shafts supported between two radial bearings; B. Shafts supported between two pivot bearings; C. Shafts supported between flanged radial bearings.

Bearings are usually secured in a housing or on a shaft by interference fits. Slight interference fits are often called "push" fits and slight clearance fits are sometimes known as "slide" fits. Bearings are also secured by ring staking, snap rings or lock nuts.

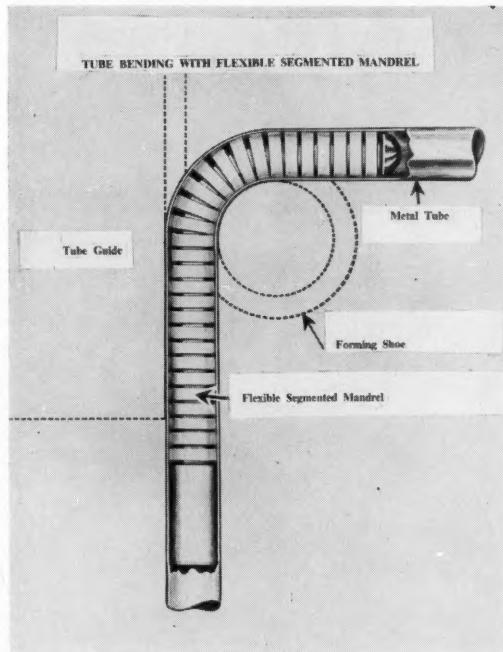
Design simplicity and minimum cost are best attained by the specification of standard miniature ball bearings whenever this is at all possible. ★



Flexible ball mandrel, flexible segmented mandrel and bullet type mandrel machined from nylon (top to bottom).

Nylon tube bending mandrels save time

The resilience of the nylon allows the mandrel to deform during bending



A nylon mandrel can be cut, formed and assembled in five hours; original steel mandrel required seven days.

Metallic tubes from $\frac{1}{4}$ in. to over 2 in. diameter often have to be bent to various configurations but must still maintain their inside diameter and not collapse in the process. For heavy wall or smaller tubes, a bullet-type mandrel (see illustration) is inserted to a spot just below the point of bend, where it remains as the tube is drawn.

The flexible segmented type illustrated is used for bending thinner wall or large diameter tubing which is more prone to collapse. It is more frequently used than the bullet type, and is inserted in the tube and travels with it around the forming shoe.

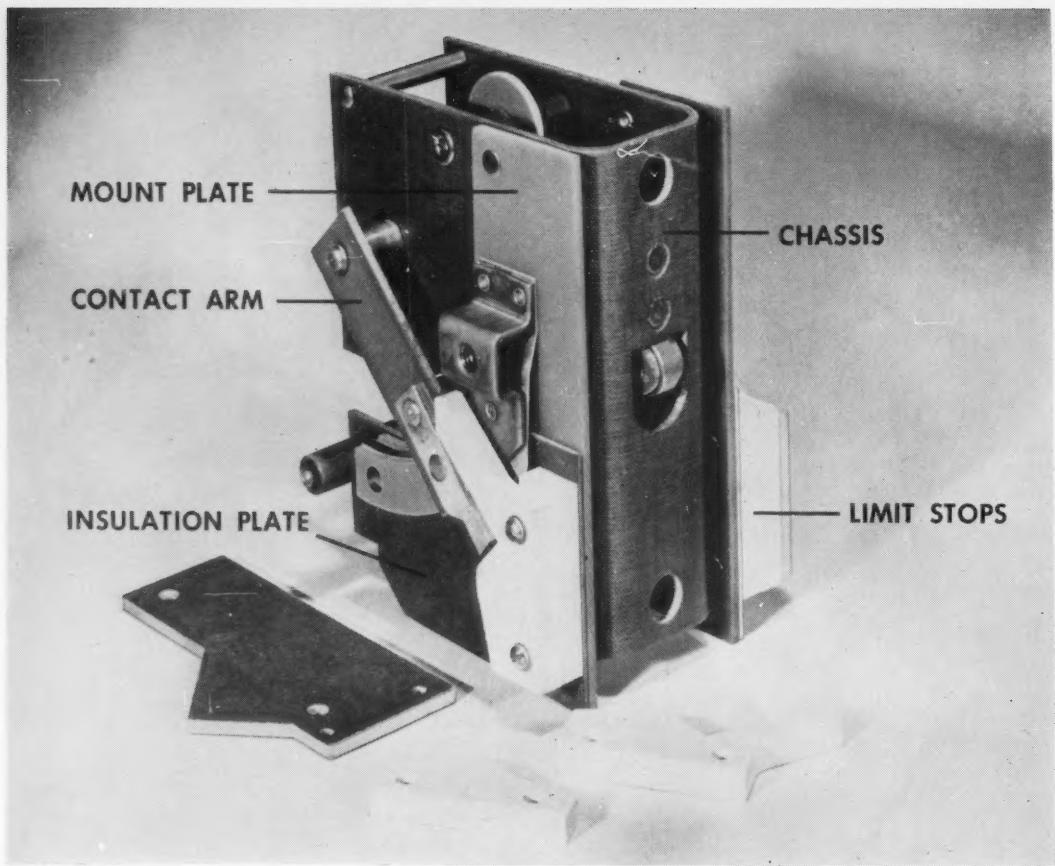
Nylon tube bending mandrels, engineered by Douglas Aircraft Co., Inc., Santa Monica, California, are reported to result in considerable savings of money and assembly time. The nylon parts for the mandrels were machined from rod stock supplied in Canada by Polypenco, Inc. of Montreal.

Douglas reports that this material has the necessary combination of properties such as abrasion resistance, high tensile strength, resilience and low friction.

The abrasion resistance of the nylon makes it long wearing. At the same time, its natural resilience allows the mandrel to deform slightly, thus distributing the load during the bending cycle and reducing chatter and vibration. The low surface friction eases the insertion and removal of the mandrel and minimizes the drag during the drawing operation, while its high tensile strength prevents tearing of the mandrel during bending.

The segmented mandrel is made up of a number of disks of ball-shaped segments with a centre hole. A flexible steel cable is threaded through these segments to form the complete mandrel. The machining of the segments is easy to carry out with standard equipment.

A segmented ball mandrel of 1 in. diameter is reported to cost only one-third as much fabricated from nylon as it does from the original polished steel. ★



Five different grades of Phenolite were chosen for the five critical components of this circuit breaker indicated.

Design

Laminated plastics fulfill a design need

Selection of a particular grade of laminate for the various components of a circuit breaker shows the wide range of properties currently available

These high pressure laminates are composed of a number of different base materials and thermosetting resins. The resultant materials possess all the inherent properties of thermosetting laminates. All are remarkably tough and light in weight and have high dielectric strength and moisture resistance. Many are well suited to a host of mechanical and electrical applications.

Paper base grades range from those intended for mechanical applications (where electrical requirements are secondary) to grades that have superior electrical and punching qualities. Grades using glass and asbestos fabric are selected for their resistance to flame and heat. Other base materials, such as cotton cloth and nylon, provide extreme toughness and resistance to corrosion.

These laminates are heat resistant to continuous temperatures of from 225 to 400 F, have low thermal conductivity and low coefficients of expansion and retain their properties even after long exposure to high humidities and severe service conditions.

There are thousands of types and grades of plastic materials available to industry today, and each has its own set of physical and electrical properties. When these properties are matched properly to the performance requirements of equipment and components, important product design improvements are possible.

One example of this is the improved circuit breaker now being produced by a leading manufacturer of electrical equipment. To get optimum performance from

each of five critical components of this breaker, the manufacturer chose five different grades of Phenolite, a high pressure laminated plastic produced by National Vulcanized Fibre Co.

The components in question include the chassis, contact arm, insulation plate, mount plate and limit stops (see figure). The choice of the particular grade of laminate was determined, in each case, by the physical and electrical properties of the components.

Chassis. Phenolite C-534F was chosen for the circuit breaker chassis. This grade has great strength, good dimensional stability and can be postformed. It permits close-tolerance forming and, since it is a good insulator, there is no need to insulate other parts from it. Grade C-534F has tensile, compressive and flexural strength values equal to the non-forming grade C-501 (see Table).

Contact Arm. To provide the toughness required in the contact arm, Phenolite C-501 was chosen. This is the high-strength laminate usually specified for gear applications. It has an extremely high impact strength and also provides the insulating qualities necessary to support a live conductor.

Insulation Plate. The arc breaks in the area of the insulation plate. For this reason, a combination material consisting of a special Phenolite core, sandwiched between two layers of vulcanized fibre, was specified. This combination gives external surfaces the extremely high

arc resistance of vulcanized fibre (150 to 180 sec rating for fibre, as against 3 to 5 sec for the core stock) and the inner core high physical strength and dimensional stability.

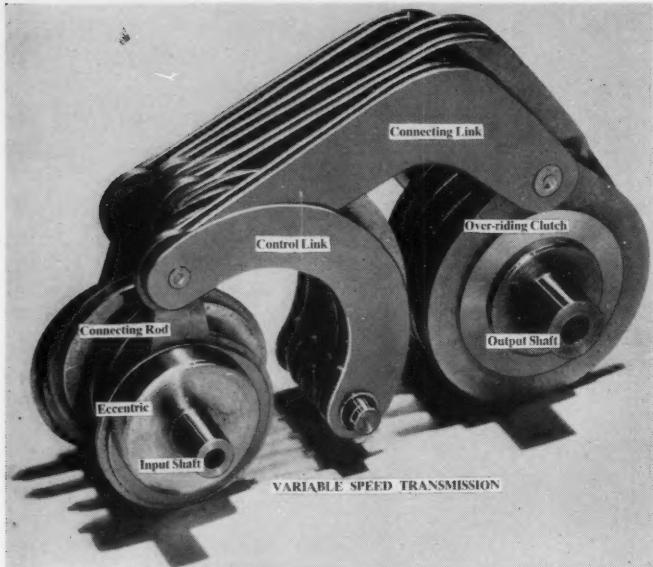
Mount Plate. To provide the high mechanical strength required in the mount plate, which supports most of the mechanism, grade P-214B was chosen. This laminate has good mechanical strength and, because of its low thermal expansion properties, good dimensional stability.

Limit Stops. A melamine-polyester grade, Y-2401, was specified for the limit stops, to give these parts good impact resistance and superior arc resistance. This special paperbase laminate permitted lower fabricating costs, since it is easily shaved to precise dimensions from pre-sawed blanks. It has an arc resistance rating of 80 sec, in comparison with ratings of 3 to 5 sec for standard paper-base electrical grades (XX and XXX). This grade also has excellent mechanical properties and an Izod impact strength rating of 0.40 to 0.48 ft-lb per inch of notch.

The manufacturer's selection of a particular grade of laminate for each of these circuit breaker components illustrates how a basic material having a wide range of properties can meet a number of different performance requirements. The five grades of laminated plastic chosen are only a few of the variations of this basic material currently available to design engineers. ★

Properties	Grade			
	C-534F	C-501	P-214B	Y-2401
Base	Canvas	Canvas	Paper	Paper
Density (gm./cc.)	1.35	1.35	1.33	1.35
Tensile Strength (psi)				
Lengthwise	11,200	11,200	10,000	17,000
Crosswise	9,500	9,500	9,000	12,000
Compressive Strength (psi)				
Flatwise	37,000	37,000	25,000	34,000
Flexural Strength (psi)				
Lengthwise	22,000	22,000	15,000	24,000
Crosswise	18,000	18,000	13,000	18,000
Izod Impact Strength (ft. lb. per in., of notch)				
Lengthwise	2.3	2.3	0.8	0.48
Crosswise	2.2	2.2	0.6	0.40
Dielectric Strength perpendicular to laminations; short time test (volts/mil)				
1/16 in.	—	—	650	775
1/8 in.	—	—	470	585
Heat Resistance (deg. F.)				
Short Time	275	275	275	350
Continuous	225	225	250	250

Table of Properties of Phenolite Laminated Plastics



Zero-Max Specifications

Input Shaft. Cold rolled steel 1020. Ends centreless ground to $\pm .0005$ in.

Eccentric. 1020 cold rolled. Hardened to 62 Rockwell C. Sides ground to $.0005$ in. OD shaved.

Connecting rod. As for eccentric. ID honed to $.0005$ in.

Connecting Link. 1020 steel.

Control Link. 1090 spring steel.

Clutch body. 4130 aircraft alloy hardened to 62 Rockwell C. Sides ground. ID honed and hole reamed, both to $.0005$ in.

Output Shaft. As for input shaft.

Assembled with 1020 CR pins through naval bronze bushings.

The connecting link actuates the over-riding clutch and makes it turn the output shaft. Specification is on right.

Component

Try this variable speed transmission

Suitable for infinitely variable drives on testing equipment, mechanical tools, packaging equipment, blueprint machines and medical equipment

A mechanical power transmission, speed control, infinitely variable speed reducer and full constant torque converter known as Zero-Max gives variable speed from top speed down to zero rpm. It can be used for infinitely variable drives on testing equipment (metering pumps), in the chemical industries (proportioners), for medical equipment (pill machines), in manufacturing (conveyors, baking machines), for office equipment (blueprint machines), on machine tools (milling spindles), for packaging equipment (labeling and marketing machines) and for electrical equipment (recorders, coil winders).

Power is transmitted from the input shaft to the output shaft by a series of connecting links mounted side-by-side and operated in phased sequence. Rotation of the input shaft moves the eccentric. When this is set in its vertical position, the connecting link merely receives an up-and-down motion and the output shaft does not turn.

If now the eccentric is set toward the output shaft, it will have a component of motion in the direction of the connecting link, which will thus reciprocate to-and-fro (as well as up-and-down, of course).

This imparts an oscillation to the over-riding clutch which works like this. When rotating in one direction

it turns the output shaft but when rotating in the opposite direction (that is, on the return stroke of the connecting link), it free-wheels.

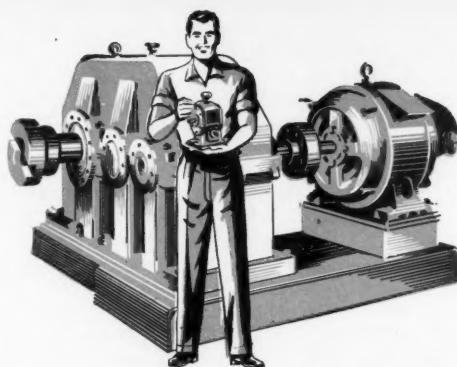
However, depending on the number of laminations in the unit, one or more clutches take hold of the output shaft and rotate it continuously. One clutch takes over, in fact, just before another lets go.

The stroke of the connecting link (and hence the amount of clutch oscillation) can be varied by means of the control link assembly, for this determines the eccentric setting.

The control link is free at one end and when set at zero the connecting rod moves straight up-and-down, there is no lateral motion of the connecting link and the output shaft remains stationary.

As the control link is moved away from zero, the connecting rod is pulled off the vertical line toward the output shaft, thus giving a lateral motion to the connecting link.

The equipment is being used by Hart Metal Fabrications Limited for machine tools and special machining equipment: Rotor Electric Company for coil-winding machines and small conveyors; de Havilland Aircraft Limited for coil-winding machines and laboratory applications: University of Toronto Department of Physics.



Hamilton Gear standard speed reducers are made in sizes ranging from units small enough to be carried easily by one man up to reducers weighing 18 tons.

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Racks



Helical Gear Reducers



Helical Gears



Spur Gears



Bevel Gears



Herringbone Gears



Worms and Wormgears



Internal Gears



Wormgear Reducers

Rugged, quiet in operation and designed for extremely long service, Hamilton Gear Speed Reducers are favoured in a wide range of industrial and mining operations. Helical gear speed reducers—like the unit pictured above—have replaced herring-bone reducers in most applications because single helical gears require no centering and take the load evenly over the whole gear face despite any external thrust. These units can be equipped with a back-stop to prevent reverse rotation—for instance when used with an inclined conveyor or bucket elevator. These versatile Hamilton Gear reducers come in ratios from 2 to 1 up to 800 to 1, in single, double or triple reduction.

For further information write for Catalogue No. 113.

**Hamilton Gear
and Machine Co., Limited.**

HG-T-3-55

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STAN STEEL
WELDED TUBING

Seamless Tubing • Fabrications •
Aluminum

Finish

New process gives Stainless a permanent coat

**Photo-chemical technique effective
with 11% minimum chromium content**

Development of a process for permanently coating and integrally-marking the surface of stainless steel has been announced by Ateenate, Inc., of Boston, Mass. The process, which they claim has not been successful before, is expected to have far-reaching effects in many industries.

The new technique, which is photo-chemical, produces a hard, highly-ductile, non-crystalline structure, in many ways more resistant to chemical and physical damage than the unprocessed metal. Since the new process actually alters the chemical composition of the steel, the markings and coatings are an integral part of the metal and are equally permanent. The process is effective on metals with a minimum chromium content of 11%.

The process will permanently mark stainless steel in jet black (for name plates, dials, schematics and the like) and will also produce a coating with properties that increase the strength of the metal, provide a much smoother surface and reduce friction and heat. It is also expected to decrease the incidence of metal fatigue.

The surface coating is impervious to heat up to 1,700 F and to acids, alkalis and abrasives. It has more resistance to wear and corrosion than the stainless steel itself. It cannot chip, flake off or peel and may be twisted, formed or bent on its own radius without damage.

It is expected to be particularly effective in the aircraft industry for coating external covers for supersonic jets and missiles and the interiors of airflow parts. Use of the process cuts down air drag, reduces friction and heat and strengthens the metal against wear and corrosion.

Independent tests by private industry indicate that in the blackening of steels, such as in guns and instrument parts, the jet black is superior to any process yet developed. A comprehensive survey of more than 300 blackening processes, from Europe and the United States, conducted for a government agency by the Henry Souther Engineering Co. of Hartford, Conn., concluded that three processes appear to give results which are superior to all others tested. They are black chromium plating, electro-phosphating and this proprietary coating. The survey further stated that only



Inspecting name plate permanently marked by process.

the Ateenate gave a coating which was satisfactory from the standpoint of appearance, abrasion resistance and lack of build-up in threads.

In the field of name plates, instrument dials, gauges and schematics, the Ateenate process permanently reproduces any design, character, diagram or message. The markings are jet black on stainless steel or the reverse.

This new process reproduces the finest detail, regardless of the complexity of the design. Lines as fine as 0.001 in. can be obtained without distortion and scales with 200 legible lines to the inch have been precisely reproduced with a tolerance of 0.002 on a length of 17 inches.

The ability of the process to reproduce such precise markings on stainless steel does away with the necessity for costly close-tolerance engravings on measuring devices, rules and scales. Permanent calibrations and numerals on dials, gauges and instruments ensure accurate interpretation of data for an indefinite period.

One of the striking features of the new process is its ability to reproduce photographs on stainless steel up to 150 screen. This opens many new possibilities in the printing field and other industries. As identification badges for security purposes and in passports, for example, such plates cannot be altered or forged.

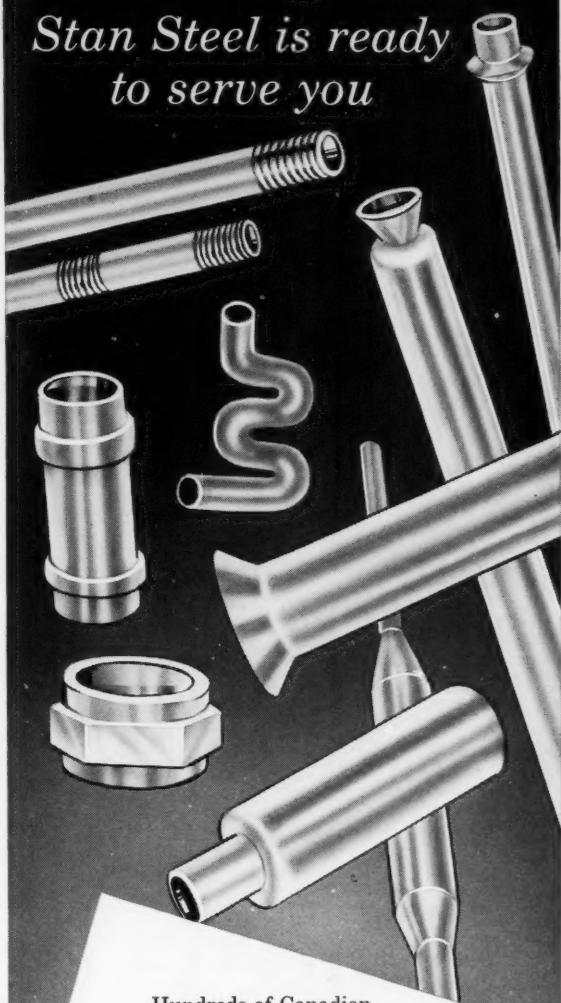
Stainless steel sheets from .003 to plate gauges, as well as rounds and shapes, take the process well. Ateenate name plates permit the use of gauges of stainless steel lighter than those required for materials used in other processes, because the metal is not deeply etched to hold the conventional enamel or lacquer fill.

Extensive tests by private industry and government agencies indicate that Ateenate coating and marking will withstand temperatures of more than 1,700 F (in air). Conventional markings on aluminum and brass disintegrate at about 170 F.

Remarkable resistance to corrosion has been found on test. The markings resisted concentrated salt spray for 100 hours, saturated sodium chloride solution (alternate immersion and air drying) for 600 hours, sulphuric acid (62 Ba.) for 336 hours, boiling in water and lye for indefinite periods and immersion in phenol derivatives for indefinite periods with no appreciable effect. ★

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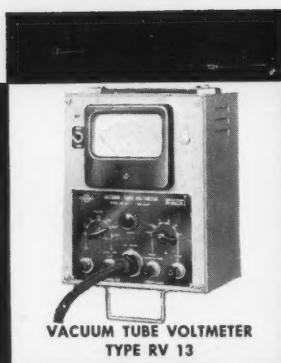
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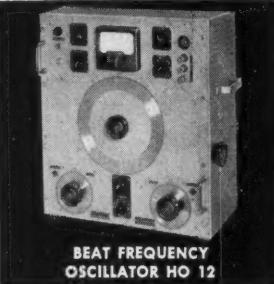
SIGNAL GENERATOR
MS 25



NOISE GENERATOR
TYPE DSG 1



VACUUM TUBE VOLTMETER
TYPE RV 13



BEAT FREQUENCY
OSCILLATOR HO 12



LIMIT BRIDGE TRB 1



AM STANDARD SIGNAL
GENERATOR TYPE MS 15



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DELAY LINE KL 41



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In the production of cylindrical shapes, and for small castings of irregular shape, the *Centrifugal Casting Method* yields a quality product much superior to that produced as a static casting.

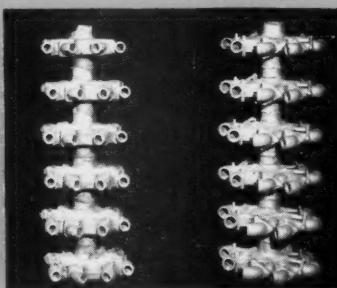
And Shawinigan PERMA-SPUN offers significant economies over drawn tubing. Even on small quantities of any

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Centrifugal Force ensures complete freedom from non-metallic inclusions and shrinkage and creates a dense, fine-grained casting with enhanced physical properties.



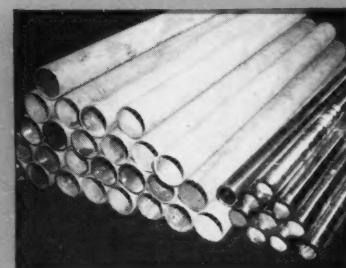
Centrifugally cast CF10M pipe for sulfite acid circulation systems.



Centrifugally cast stacks of CF8 fittings (as cast condition).



Centrifugally cast HU retorts for magnesium production.



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Illustrated are a few of the many applications of **PERMA-SPUN** corrosion and heat-resistant stainless steel. Consider the possibility of saving money in your operations with "Shawinigan" **PERMA-SPUN** centrifugally cast Stainless Steel!

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STAINLESS STEEL AND ALLOYS DIVISION

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This is a new model
(causing some anxiety)

with a few bugs
(holding up production)

which could be ironed out
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by a dependable source of castings
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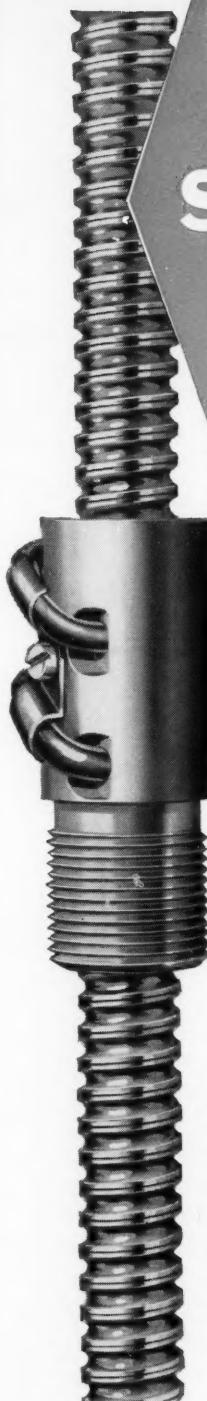
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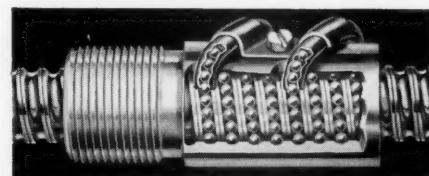
Provide 4 times more efficiency than conventional screws—and require only 1/4 of the power. Reduce size, weight, cost of entire unit.

Here's great news for every manufacturer who uses Acme screws or hydraulic actuators in his product! Saginaw now offers Rolled-Thread Saginaw b/b Screws in standard sizes at amazingly low mass-production cost.

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ROLLED-THREAD SAGINAW b/b SCREWS ARE NOW AVAILABLE IN THESE STANDARD SIZES AND ANY SCREW LENGTH:

Ball Circle Diameter	Ball Size	Lead
.375	.0625	.125
.631	.125	.200
1.000	.15625	.250
1.171	.28125	.41304
1.500	.34375	.47368
2.250	.375	.500
3.000	.500	.660

ROLLED-THREAD SAGINAW b/b SCREWS ARE ALREADY BEING SUCCESSFULLY USED IN THESE TYPICAL APPLICATIONS:

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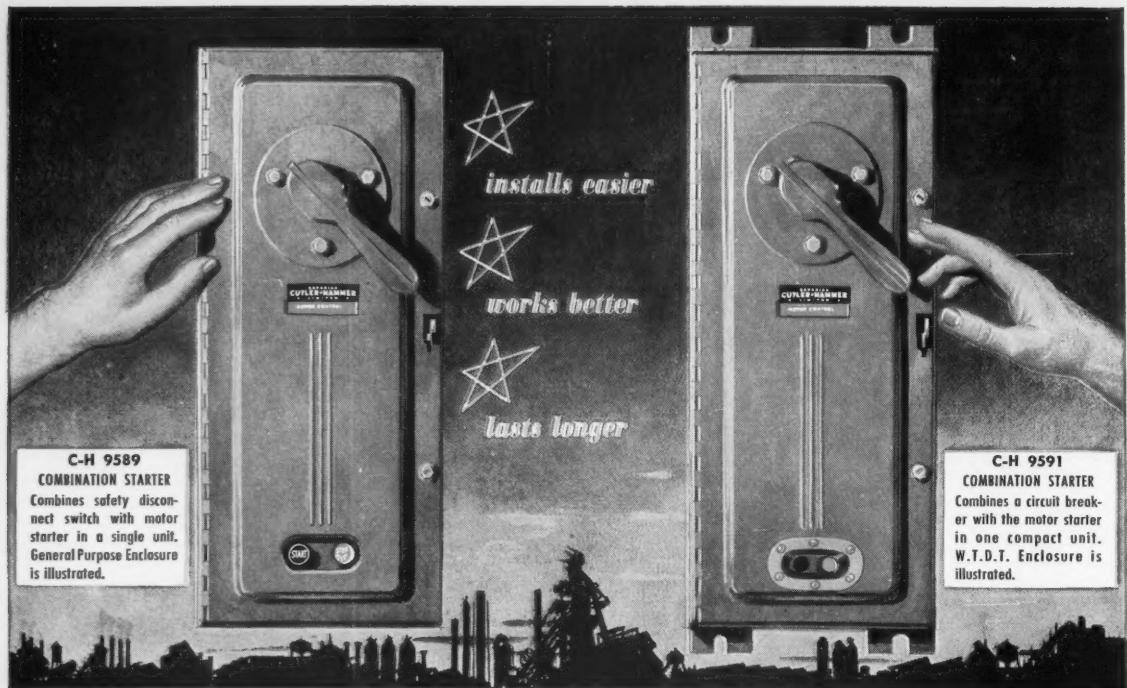
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Combines safety disconnect switch with motor starter in a single unit. General Purpose Enclosure is illustrated.

C-H 9591

COMBINATION STARTER
Combines a circuit breaker with the motor starter in one compact unit. W.T.D.T. Enclosure is illustrated.

New Canadian Cutler-Hammer Three-Star Combination Starters offer industry important new economies

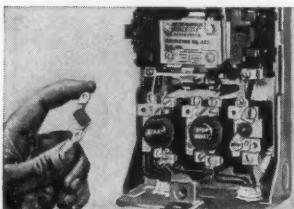
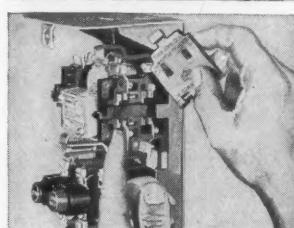
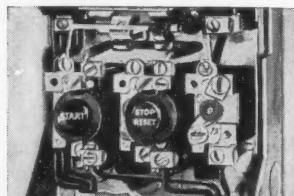
Users everywhere say the new Canadian Cutler-Hammer * Combination Starters set new standards of convenience and economy.**

HERE ARE REASONS WHY:

- Contact life is so amazingly improved that maintenance care is NEVER needed in all normal uses.
- Adjustable load sensing coils permit motor to work at top capacity without hazard to provide maximum production without needless work interruptions.
- The widely-praised Canadian Cutler-Hammer EXCLUSIVE, full three-phase overload protection in standard combination starters, is optional at slight additional cost.

The remarkable new Canadian Cutler-Hammer *** Combination Starters should be compared for convenience and economy against any others you know or use. Canadian Cutler-Hammer Bulletin 9589 Combination Starters incorporate rugged disconnect switches of advanced design (fused or unfused). Canadian Cutler-Hammer Bulletin 9591 Combination Starters are equipped with circuit breakers.

Contact your nearest Amalgamated Electric district office or write for Bulletins 9589-9591.



Full Three-Phase Protection

Only three overload relays can give complete three-phase protection to avoid motor burn-outs and their costly interruptions to production. And only Canadian Cutler-Hammer offers this complete three-phase protection in standard combination starters. You pay only for the third relay, nothing extra for special engineering or special enclosures.

Adjustable Load Sensing Coils

The accurate adjustment of overload protection permits motors to work harder without damage to motor windings. This is more important than ever with the newer type small frame motors. Adjustable load sensing coils in these new starters provide 3% loading accuracy instead of 10% to 12% accuracy in competitive control.

Superlife Vertical Contacts

Experienced control users insist on dustsafe vertical contacts. And now the famous Canadian Cutler-Hammer vertical contacts have been doubly improved. First, their new lightweight design cuts bounce to reduce arcing. Second, any arcing that might occur is now pressure-quenched. Compare performance and see the difference.

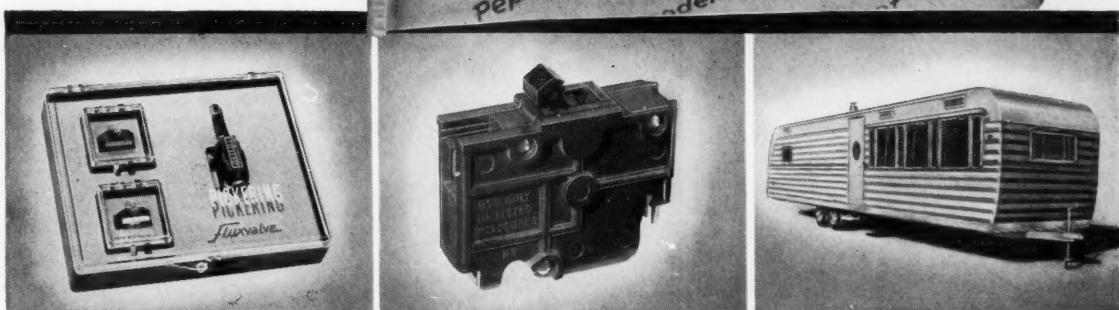


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Catch the eye to capture the sale

CAPS IN COLORS AID BRAND RECOGNITION: Colorful closures made of BEETLE® Urea Molding Compounds identify many leading brands of toiletries and pharmaceuticals. BEETLE offers countless design opportunities in the color of your choice. It's stain resistant, reasonably priced, attractive to the eye and hand. Step up the competitive appeal of your package with colorful, quality BEETLE!



DELICATE HI-FI COMPONENTS NOW "WRAPPED" IN TOUGH PLASTIC: The Pickering pickup and stylus are made virtually impervious to shock, wear and humidity by embedding the sensitive parts in LAMINAC® polyester resin. The one-piece, self-enclosed units are easy to assemble and finish...stylus units are colored to identify type and size.

CONSIDER THE CASE OF THIS HOME CIRCUIT BREAKER: Federal Pacific Electric Company's home circuit breakers are cased in low-cost brown BEETLE 1005. Advantages: high arc resistance, high dielectric strength, good moldability, speedy molding cycles with low scrap loss. Consider the case BEETLE might make for your electrical parts.

NOT A NAIL ANYWHERE! All joints in the Anderson Coach are electronically "welded" with URAC® Resin 183, which makes joints actually stronger than wood itself...much stronger than nailed joints. Use this gap-filling, craze-resistant, moisture-resistant resin adhesive for strong, sure bonds in assembly gluing and lamination.

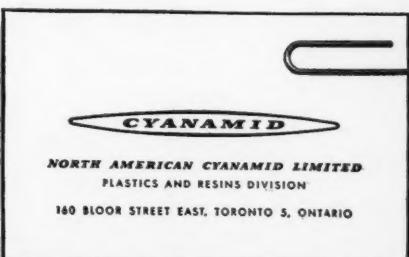
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Call Cyanamid for advice and cooperation in melamine
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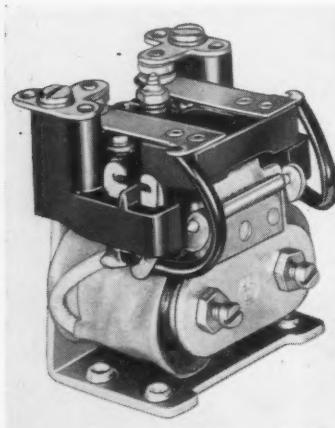


New products & materials

New items which can help you on the job

JUST ADDED AS A stock model to the line of OHMITE MANUFACTURING CO. Amrecon all-purpose relays is Model DOSY. This is equipped with twin coils to increase the magnetic efficiency (sensitivity) of the relay by allowing a greater number of turns for a given wire size and a greater operating force therefore for a given power input.

This increased operating sensitivity makes the DOSY relay suitable for a wide range of electronic control circuits, such as plate circuit controls and so



Not-so-dosy relay

forth. Other industrial uses are as an overload or underload control. Here the relay would be used in a DC circuit to obtain a signal indication when the control current increases above a predetermined maximum or drops below a predetermined minimum.

The insulation is of high-grade molded phenolic material. At 115 VAC (or 32 VDC) non-inductive load, the relay has a contact rating of 15 amps. (200)

Speedy new clip fastener

THE ATTACHMENT OF INSULATION to steel roof decking is now much simpler and more efficient than ever before—thanks to the efforts of two Canadian companies working hand in hand to find the solution to a very difficult problem. The result, a truly Canadian development that is so outstanding that it is now being adopted in the U. S.

Robertson-Irwin Limited, a major supplier of steel roof deck to the Canadian

construction industry, were looking for a means of fastening insulation of all types to their steel roof deck which would eliminate the fire hazard. They presented their problem to DOMINION FASTENERS LIMITED, manufacturers of the famous line of SPEED NUT brand spring tension fasteners. After a great deal of experimenting and development Dominion finally came up with a fastener that solved the fire hazard as well as all the major installation problems.

The fastener, called SPEED CLIP, is made from high quality, heat treated spring steel. Its application is fast and simple and when man-hours and materials are considered, it is proving to be much more economical. The whole insulation operation is simplified and there is no necessity to pierce the deck. The hazards and high costs of winter construction are eliminated and a sure, permanent attachment provided.

The clip is inserted into the flute of the roof deck against the insulation board and a simple tool is positioned on the foot of the clip and given one or two sharp blows with a hammer. This is enough to seat the clip and to make a positive anchor between the insulation and the deck. Other variations of the clip have been developed for the many different types of insulation. (201)

New elastomeric adhesive

FOR CONTACT AND hot bonding a wide variety of porous and non-porous surfaces, a new elastomeric adhesive is now available from Adhesives & Coatings Division, MINNESOTA MINING & MANUFACTURING COMPANY. Called EC-1357, it can be used in bonding metal frames to veneered plywood, aluminum sheets to aluminum channels and decorative plastic laminates to metal counter and table tops. It can also be used as an adhesive for sandwich construction.

The adhesive has a rapid strength build-up rate, high adhesion to steel, high softening point, excellent resistance to plastic flow and sprays well. When used as an adhesive to bond honeycomb structures, it provides about double the peel strength of similar structures fabricated with resin-type adhesives.

Production hot bonding of parts with EC-1357 can be accomplished with relative ease and speed. Surfaces of parts to be bonded are chemically cleaned and the adhesive applied with a hand roller or by spraying with conventional spray

equipment. The adhesive is dried with infra-red heat. The parts can then be hand-assembled and bonded while hot by one pass through a pressure roll. Air drying methods can be used in conjunction with hand rollers for low-production bonding. (202)

Solenoid controlled hydraulic valves

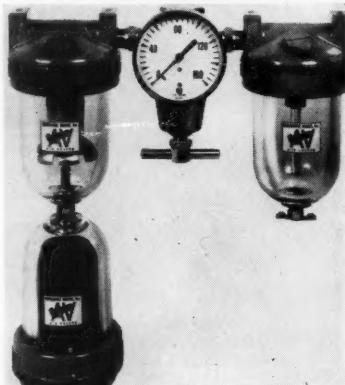
AN IMPROVED LINE of solenoid operated and solenoid controlled, pilot-operated directional valves for industrial oil-hydraulic systems is now available from VICKERS INCORPORATED. Ample room is provided in the valve body for making electrical connections, thereby eliminating the need for a separate conduit box.

The new valves are improved models of the familiar Vickers DG Series. Available for gasket or subplate mounting, they are compact and require a minimum of piping. Mounting dimensions remain unchanged. (203)

Air control assembly

SLUDGE FORMED BY dirt, scale, rust or moisture is automatically trapped by a filter manufactured by AIRMATIC VALVE, INC. This new air control assembly automatically filters, regulates and lubricates compressed air used in the operation of pneumatic equipment.

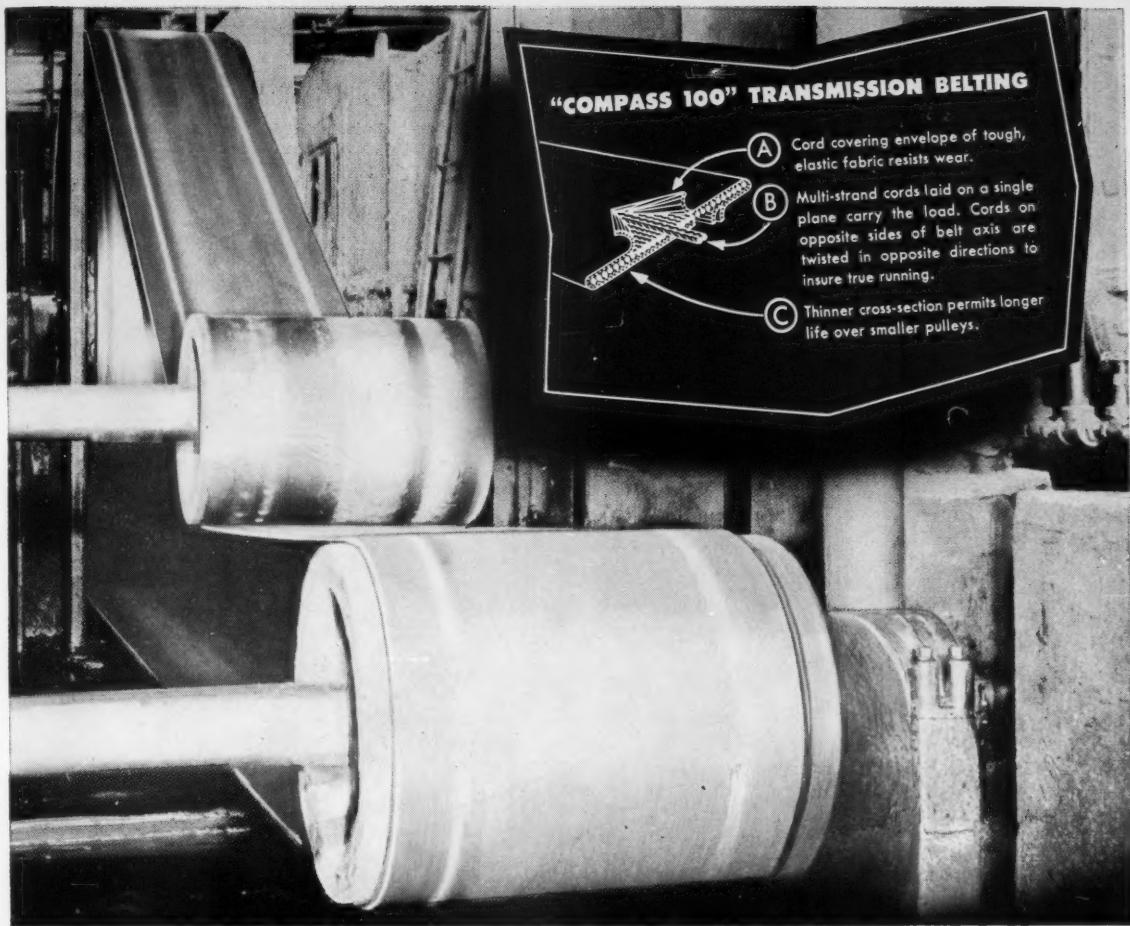
Sludge causes corrosion and excessive wear to precision parts of air-operated equipment. An automatic drain trap attached to the bottom of the filter collects moisture from the filter and thus eliminates periodic draining maintenance.



Sludge trapper

After the cleaned air has been regulated to the desired pressure, a fine oil mist is added by the lubricator. This lubricated air is carried to the operating parts of the equipment.

The air control assembly provides visibility of operation of each unit while up to 98% of free moisture is removed, with negligible loss of air pressure. (204)



How belt costs were cut 60%

Belt replacement expense and high maintenance costs plagued management of a Toronto paper processing plant. Transmitting power on a beater drive to agitate 30 tons of reclaimed paper mash, 24 hours a day, 6 days a week at 500 r.p.m. by a 250 Hp. motor, added up to a belt-killing drive.

Troubles ended, however, when a Goodyear Representative stepped in and recommended a "Compass 100" Belt. For 2½ years, this 30" "Compass 100" has successfully absorbed the gruelling punishment of this tough operation.

The cost of "Compass 100" for 2½ years' service was approximately equal to the cost per year of the previous belt.

The Goodyear "Compass 100" Belt now on the job looks like it's going to stay on the job for a long, long time, cutting costs at every turn.

Every inch of Goodyear belting is backed by 50 years of experience in producing rubber products. This vast store house of know-how is available to help you solve problems of power transmission or material handling thru' industrial rubber products.

GOOD  **YEAR**
INDUSTRIAL RUBBER PRODUCTS ENGINEERED FOR THE JOB

For complete information write or call your nearest Goodyear office at—Moncton, St. John, Quebec City, Montreal, Toronto, London, Windsor, Winnipeg, Regina, Saskatoon, Calgary, Edmonton, Vancouver or Head Office, New Toronto.

New Products

(Continued from page 60)

A NEW LINE of lifetime watthour meters, specifically designed to accommodate higher future loads with straight-line accuracy, has been introduced by the CANADIAN WESTINGHOUSE COMPANY.

With each socket-type DS or bottom connected DA meter, the company guarantees the replacement of any part which fails under proper and normal use up to 30 years from shipment date. This feature will reduce maintenance costs for the utilities.

These new single phase, three wire meters will measure loads accurately from 0.75 to 100 amperes. A socket-type meter with a range from 2 to 200 amperes will be placed on the market by the company in the future and will handle any foreseeable single-phase loads.

All meter components are precision manufactured to exact mechanical, electrical and magnetic tolerances. Register, bearings and moving element are interchangeable on all DA and DS meters without mechanical adjustments, while electromagnets and frame assemblies of DA and DS meters are respectively interchangeable. High insulation level to withstand extreme voltage surges is backed up by built-in lightning protective devices which discharge to the ground well below insulation breakdown point.

The potential coil is now vacuum impregnated with Laminac thermosetting polyester resin drawn into every layer of the winding and the heavy formwound current coils are molded in a resilient polyester compound. The insulation level in both coils is 10,000 volts, 60-cycle rms.

Higher thermal capacity in the meter is achieved through the use of heavier wire, better connections and improved insulating materials. There are only two adjustments to make on the meter, the full load and light load. Both are linear, and can be operated by hand or screwdriver.

(205)

Fused silica windows

CAMERA WINDOWS maintaining high optical qualities under the extreme temperatures experienced in wind tunnel operations and ultrasonic missile work are now available from CORNING GLASS WORKS.

The excellent Schlieren optical properties of the windows make them ideal for accurate observation of high speed pressure patterns in wind tunnels.

Made of fused silica, the windows have a low index of refraction variation (about 2×10^{-6} per in.) and can stand temperatures up to 990 C. They can be

used to protect cameras and other delicate recording instruments from the skin temperatures of high-speed aircraft or guided missiles.

The windows are extremely resistant to thermal shock. They have a thermal expansion coefficient of 5.6×10^{-7} per degree C.

Fused silica windows have high transmission in the ultraviolet range and do not darken under gamma radiation and electron bombardment.

The windows are normally available up to diameters of 17 in. Special orders for larger windows can be taken.

With high electrical resistivity and low dielectric loss (less than 0.0008 at 200 C and 1 megacycle), fused silica glass makes an excellent insulator for high voltages.

The extremely low ultrasonic attenuation of this material (less than 0.03 decibels per ft per megacycle) also makes it an ideal medium for solid ultrasonic delay lines.

in. diameter and currents up to 1,200 amperes.

Compatibility with older apparatus is also a feature of the design. The new welding heads and mounting accessories can be used with presently available controls and carriages without changing the electric wiring.

(207)

Recording milliammeter

A RECTILINEAR RECORDING milliammeter, with all its associated advantages, is now available from COMPUTING DEVICES OF CANADA LIMITED. Signals are presented in their true rectilinear appearance, eliminating the need for complicated data reduction.

It is an ink-writing, galvanometer instrument, with front access for all routine operations. Features adding to convenience in use include: front located signal terminals (rear terminals optional); front located switches and controls; writing desk area on chart for notations; front filling ink system, and swinging chart-paper carriage.

Rectilinear writing is made possible by a new pantographic linkage. This includes a jeweled gymbal mounting for the pen and a freely moving A-frame, with counter-balancing weights to give uniform pen pressures.

The recorder weighs less than 27 lb and has the dimensions 15 in. by 9 in. by 8 1/4 in. Electrical characteristics are: one milliamperc for full scale deflection; 1500 ohms input resistance, and an un-damped natural frequency of two cps. Ten speeds are available for the chart, making the 100-ft roll good for continuous recordings of from 100 min. to 60 days.

(204)

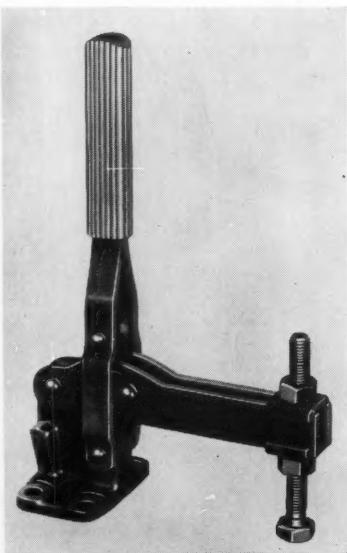
Strain Gauges

NEW BONDED RESISTANCE strain gauges made of metal foil, for use at normal atmospheric temperatures, are available from BALDWIN-LIMA-HAMILTON CORPORATION. These gauges are offered for experimental and trial use on a no-guarantee basis, in kits including 20 gauges, cement, working tools and instructions.

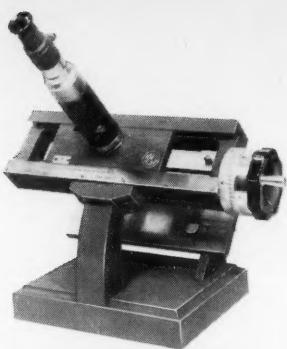
The gauges consist of a 0.0005-in. thick copper-nickel foil grid on an epoxy resin backing. Active grid dimensions are 1 in. by 11/32 in. and mounting dimensions are 1 1/2 in. by 1/2 in. Nominal resistance is 119 to 121 ohms, each package of ten gauges having a resistance tolerance of ± 0.2 ohms. The gauge factor is approximately 2.20. Application procedure is approximately the same as for SR-4 wire gauges.

Foil-type strain gauges have several advantages over wire gauges. One is that they can be made in any conceivable two-dimensional pattern. This permits fabrication of special purpose gauges that may be impractical with wire.

(209)



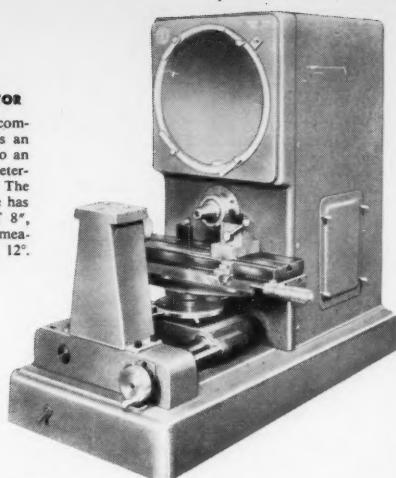
Case-Maul toggle clamp

**MICROMETER SLIDE (Mounted)**

A measuring gauge that may be used with a microscope to provide linear measurements—direct readings to .0001". This instrument is also available with a metric scale; vernier reading to .001 mm. The slant stand is equipped with mirror for reflex illumination.

CONTOUR PROJECTOR

A bench type optical comparator which projects an accurate contour on to an 8" screen, to any predetermined magnification. The precision-ground table has a horizontal travel of 8", vertical travel of 2½"; measures helix angles to 12°.

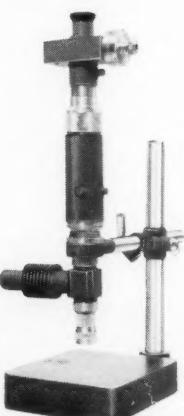


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Precision Measuring Instruments

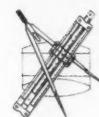
**CATHETOMETER**

An optical height gauge for vertical measurements, accurately reading to .1 mm. at distances up to 10 ft. The scale is also available graduated in inches. This device has a measuring range of 75 cm.; telescope magnification—15x.

**MEASURING MICROSCOPE AND ACCESSORIES**

A test base with a measuring microscope. A vertical illuminator may be used when slide illumination is not adequate. The Filar Micrometer eyepiece makes possible measurements of objects to .001".

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Precision
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PSC Applied Research Limited, for the first time in Canada, offers extremely accurate, optically assisted, physical measuring instruments of Canadian design and Canadian precision manufacture. Backed by the reputation of one of Canada's most progressive engineering and production companies, these measuring instruments are available now to all fields of industry. Literature and quotations on request. In the Western Provinces, please address enquiries to: Physical Measurements Company Limited, 1438 Erin St., Winnipeg 3, Manitoba.

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G-E PERMANENT MAGNETS

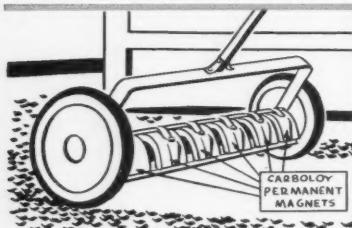
can help you solve
production and design problems



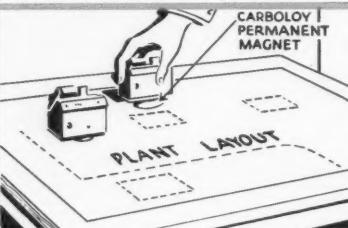
MAGNETIC TOOL RACK



MAGNETIC I-BEAM CONVEYOR



MAGNETIC CHIP-SWEEPER



MAGNETIC PLANT LAYOUT BOARD

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sleeve that has holes along its length and diameter. These holes lead to the individual cylinders. A free piston shuttles back and forth within the sleeve under fuel pressure, uncovering inlet and outlet ports. The travel of this piston is limited by a control stop which is linked to a device for measuring manifold pressure and spring loading. Corrections for air pressure and air temperature can be applied. A mechanical over-ride is provided for cold starting and warm-up.

In the systems so far described, fuel is metered to the cylinders in individual timed charges. An alternative method is to deliver fuel to the intake ports in a continuous flow or dribble.

In the continuous flow system, fuel is pumped to the engine cylinders by a common displacement pump, but unlike the Lucas system, there is no timing distributor valve. Most of the fuel is delivered to the intake port during the non-suction part of the engine cycle and is drawn into the cylinder when the intake valve opens on the intake stroke. This eliminates line inertia problems. A major difficulty is to keep the fuel from boiling in the line under manifold depression at idling and part throttle. Since the spray nozzle settings vary, it is still necessary to proportion the fuel accurately to each cylinder. Another problem is the susceptibility of the fuel line to clog because the fuel metering orifices must be very small (about 0.006 in.) for a proper idling mixture.

In the Fuelcharger Corp. system, fuel is supplied to each nozzle (an open hole with no valve) from a common fuel line. The pressure and rate of flow in this common rail is regulated by a small electric fuel pump in the fuel tank. Engine speed and manifold pressure control the speed of this pump through a special generator attached to the engine generator. Pump pressure varies from 3 lb at idle to about 160 lb at full throttle. The fuel lines are immediately filled with fuel when the starter switch sends current from the vehicle battery to the fuel pump.

The carburetor injection system is closer to the concept of the conventional carburetor. In an ordinary carburetor system, fuel is metered and delivered into the air stream at practically the same point and by the same pressure potential. When these functions are separated, as in an injection carburetor system, it is possible to do several things to improve performance.

The fuel metering force may be amplified by a supplementary pump. Fuel can

(Continued on page 72)

How C.S.I. "clean casting" methods produce better wringers for Connor washing machines—and cut production costs!



Wringer frame for the Connor washing machine, sand cast in aluminum alloy by Canadian Steel Improvement Limited.

When J. H. Connor & Son Limited, Hull, Quebec, makers of famous Connor washing machines, asked Canadian Steel Improvement Limited to cast their wringer frames, they obtained a better part at a lower unit cost.

Here's why: C.S.I. "clean casting" methods mean parts that are free from internal defects held to close, accurate dimensions extremely smooth surfaced.

The high quality of C.S.I. castings gives greater control over the alignment of roller bushings, reduces machining operations, and the smooth surfaces take a high gloss finish with minimum preparation. Starting from the competitive initial cost of these ideal wringer frame castings from Canadian Steel Improvement Limited, the manufacturer cuts assembly costs right down the line.

If You Have a Casting Problem, Call C.S.I.

C.S.I. "clean-casting" methods apply to sand castings in Aluminum and Magnesium and to Permanent Mould and Pressure Die Castings in Aluminum.



**CANADIAN STEEL IMPROVEMENT
LIMITED**

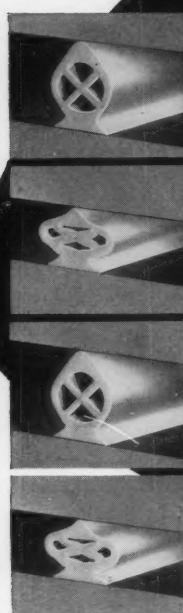
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Forgings in Steel, Aluminum, High Temperature Alloys, Titanium • Castings in Aluminum and Magnesium.

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AT -70°F
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+450°F



**GARLOCK SILICONE
RUBBER PRODUCTS**

remain flexible at both high and low temperatures . . . ideal for gasketing on electrical and steam appliances, automotive and aircraft products.

Won't stick to metal at high temperatures, either. And, silicone has no odor or taste, will not contaminate or corrode adjacent parts. Let us know your requirements. Garlock is equipped to handle even the most difficult thin wall extrusions.

Extrusions and molded parts of Silicone Rubber are only part of "The Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals to meet *all* your needs. It's the *only* complete line . . . it's one reason you get unbiased recommendations from your Garlock representative. Call him today or write for Folder AD-147.

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GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals,
Rubber Expansion Joints



Reports

(continued from page 5)

GRANBY, P.Q.—Increased participation in the growing Canadian market for all types of industrial and outdoor lighting equipment has resulted in a major expansion in the Canadian Westinghouse Company's Lighting Division.

R. H. Williams, general manager of the firm's Industrial Products Group, has announced that the division has acquired 40,000 sq ft of manufacturing and office space at Granby, Que.

Westinghouse already has facilities for the manufacture of lighting equipment at Granby in a 20,000-sq ft plant.

At present 100 employees are engaged in the production of industrial, street, sports, aviation and other types of lighting at the Granby division. The latest expansion is expected to increase employment.

Cost of the new operation is about \$500,000.

• • •

CSA holds meeting

OTTAWA—The theme of the 29th annual meeting of the Canadian Standards Association held at the Nova Scotian Hotel, Halifax, on June 8 was "Strength through Standards."

Dr. M. R. Foran, Professor of Chemical Engineering at the Nova Scotia Technical College, was the guest speaker at the luncheon. His subject was "Strengthening the Provincial Partnership through Standardization."

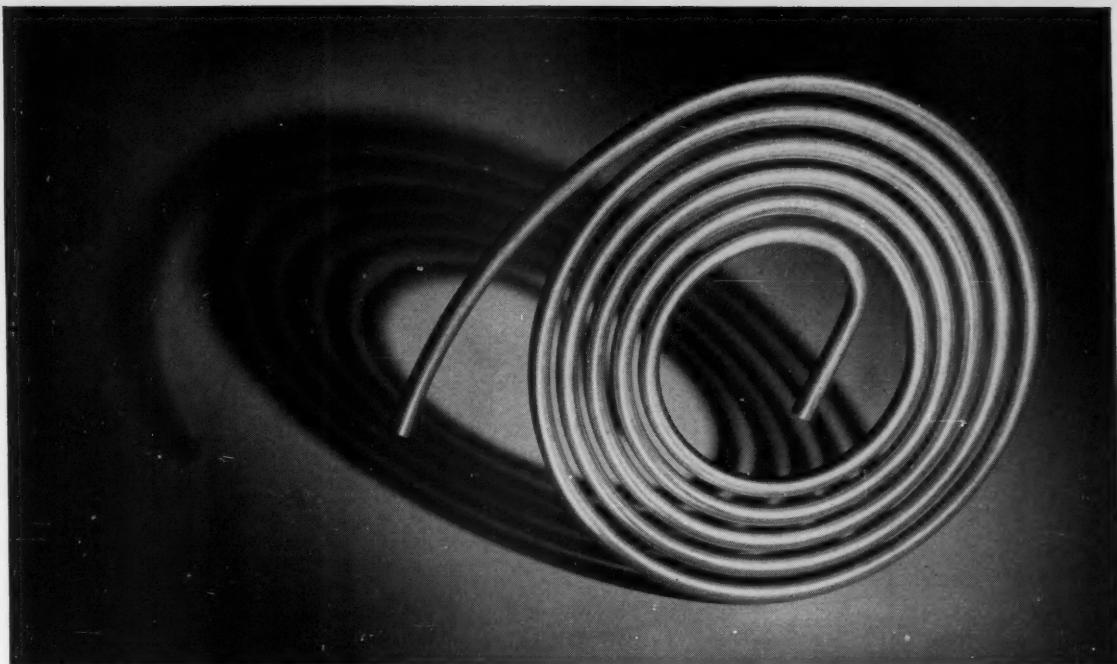
The CSA has completed its thirty-seventh year of service to Canada in the development of uniform, nation-wide standards of products, processes and procedures.

• • •

Big conversion job for Westinghouse

HAMILTON, ONT.—A contract to convert the Paugan generating station of the Gatineau Power Company has been won by the Canadian Westinghouse Company. It calls for the conversion and replacement of parts necessary to change seven 28,500 kva, 128.5 rpm vertical water-wheel generators for 60-cycle operation. All the generators were originally manufactured by Westinghouse.

In order to shorten down-time on the generators, all the redesign and fabrication work necessary on the project will be done at the Hamilton plant. In this manner it is expected that none of the generators will be out of service for more than two months. Engineering work will require approximately three months before the work can be started.



Superior offers the widest range of sizes and alloys in top quality instrument tubing

Superior Tube Company produces the finest instrument tubing in a wide range of sizes and alloys—offers you as standard products what many makers would classify as specialty tubing.

1. NEEDLE TUBING

The stainless steel links in this recording instrument are made of Superior needle tubing. The high strength, stiffness, and strict dimensional tolerances characterizing this tubing—originally designed for surgical uses—have opened new fields of industrial applications when used as mechanical tubing.

2. PRESSURE AND SUPER PRESSURE TUBING

A spiral windpipe made of Superior 304 cold-drawn seamless stainless steel tubing. Pressure tubes are used to convey fluids at elevated temperatures and pressures. Produced in stainless, carbon and alloy steels in sizes to withstand pressures up to 100,000 psi.

3. BOURDON TUBING

A "C" tube element for a pressure gage. The shaped Bourdon tube serves as the actuating element for the majority of pressure indicating and recording instruments. Helix and spiral elements are also fabricated from the wide range of alloys available at Superior—a range that makes it

possible to satisfy any set of conditions in the use of Bourdon tubing.

4. CAPILLARY TUBING

A thermostatic instrument pressure transmission element with a coiled unit made of Superior Type 321, capillary tubing. Superior capillary tubing is used primarily for transmitting temperature and pressure impulses from the source to a recording or indicating instrument. Capillary purposes, in general, require a heavy-wall tube with an ID of .006" to .030". Types 347, 321, 316, MONEL® and carbon steels are recommended analyses.

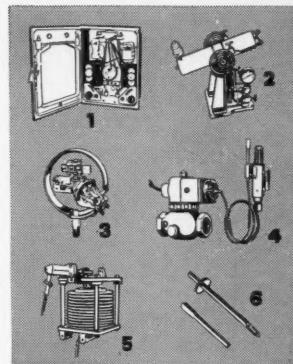
5. LARGE OD LIGHT WALL TUBING

A large OD light wall tubing bellows in a pressure actuating element. Present applications for large OD light wall tubing include bellows, low pressure heat exchanger tubes, flexible hose, aircraft ducting, fractional horsepower motor casings, ceramic drills, and casings for radioactive well logging instruments. Sizes offered up to $2\frac{1}{2}$ " OD.

6. MECHANICAL TUBING—INSTRUMENT LINE

Various fabricated parts—all made of Superior mechanical tubing. Superior mechanical tubing can be either seamless or WELDRAWN† grade used statically or dynamically, but not subjected to severe temperature or pressure. It is produced in sizes up to $\frac{5}{8}$ " OD within production limits, in many special shapes, and in over 63 standard analyses and mechanical properties.

Round and shaped tubing available in Carbon, Alloy and Stainless Steels; Nickel and Nickel Alloys; Beryllium Copper; Titanium; Zirconium



Send for free copy of Bulletin 40—
A Guide to the Selection and
Application of Superior Tubing.
Write Superior Tube Company, 2032
Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010" to $\frac{5}{8}$ " OD. Certain analyses in light walls up to $2\frac{1}{2}$ " OD

Lyman Tube & Bearings, Ltd., Montreal, Toronto and Winnipeg
Alloy Metal Sales, Limited, Montreal, Toronto and Winnipeg
Robert W. Bartram, Montreal

Book Department

Legal Problems in Engineering

WRITTEN BY AN ENGINEER who is also a practising lawyer, DR. MELVIN NORD, LLB, this book is designed for use and reference by engineers. It does not claim to make the engineer independent of lawyers but it will help him avoid legal problems before they arise and work more effectively with lawyers if they do.

The book is broad in its scope and coverage. It deals with almost every legal subject that has any bearing on engineering, and its treatment of each topic is deep and thorough. This breadth and depth is possible, it is claimed, because of a number of space-saving features, such as the elimination of detailed documentary examples, like specifications, which are readily available elsewhere.

Space has also been saved because the book does not attempt to combine law and economics. Economics cannot, of course, be entirely divorced from law, so wherever economics affects the law or its engineering aspects, the topic is fully developed. But Dr. Nord has not fallen into the trap of trying to make one book do the work of two. This is a book on legal problems and emphasis is very properly on law.

A special feature of the book is its treatment of case material. Instead of following the usual, voluminous case-book approach, cases are used to illustrate the discussion and to show the legal problems that may be encountered in a given set of circumstances. They are presented in a condensed form, designed to eliminate unnecessary side issues. There is a minimum of legal jargon and the treatment is particularly valuable to the non-lawyer seeking a concise, reliable survey of the field.

The book sells at \$7.50. It is published by John Wiley and Sons.

Science Milestones

FEW INDEED ARE there who will not enjoy this collection of dramatic stories of scientific achievement and the men behind it.

Choosing at random, details are given of how Archimedes, the father of experimental science, terrified his country's enemies with catapults hurling huge boulders; of Leonardo da Vinci's early experiments with flight; of Galileo, whose experiments marked the foundation of mathematical physics; of Robert Boyle, on the physical properties of gases; and of a host of others such as Newton, Bernoulli, Watt, Faraday, Darwin, Mach and Goddard. All names well-known to engineers.

For reading of a more lighthearted nature, this book is recommended. It is published by Thomas Allen Ltd.

New booklets and books written for you

THE SUBJECT OF direct connected fans is dealt with in a leaflet from PROPELLAIR.

These fans are available in sizes from 12 in. to 60 in. with air delivery ratings from 1,020 to 85,000 cfm free air. They are suitable not only for general duty in window or panel mountings, but also in roof ventilators, hoods or duct work, where relatively high resistance drop is encountered. In general, they may be specified for all applications where it is permissible for the motor to operate directly within the air stream.

Bayonet Saw

HOW TO USE the model 148 bayonet saw is fully explained in a PORTER-CABLE MACHINE COMPANY booklet.

It is a portable electric jig saw that operates on a new cutting principle — orbital motion. This motion moves the blade into the work on the upstroke and backs it away from the work on the return stroke, and eliminates the blade drag common to reciprocating type saws.

The orbital motion has three distinct advantages. First, by eliminating blade drag it also eliminates blade-breaking heat and friction.

Secondly, the blade teeth stay sharp longer and 30% more cutting per blade is claimed over reciprocating saws. Third, the rate of cut is four times that of reciprocating jig saws. This tool will do fast and efficient work in the wood and metal-cutting fields. In addition, it is a valuable tool for the home owner and home craftsman.

Synchronous Reluctance Motor

A NEW TYPE OF synchronous reluctance motor is dealt with in a leaflet from CANADIAN ALLIS-CHALMERS LTD. Called the induction motor, it has already been built in sizes from fractional horsepower ratings up to 40 hp. The fractional units are built on integral horsepower frame sizes.

The motor may be used where the application requires constant, unvarying speed; where two or more motors must operate in synchronism, with the same speed relationship; where speed must be adjusted to certain fixed values over a rather wide range and remain constant at each fixed value.

Briefly, the motor may find applications wherever synchronous reluctance motors are now used.

The most promising application of

this type is in the synthetic fibre industry where large numbers of small synchronous motors are required. Another application could be on roller conveyors, where each powered roller must operate at exactly the same speed as other powered rollers in the same system.

Quad Rings

LONGER WEAR and more effective sealing are two features of the QUAD-RING as compared to other seals, according to a leaflet published by MINNESOTA RUBBER AND GASKET CO., who have been testing their new seals in various industrial applications.

As an example, the Wilton Tool & Manufacturing Co., Chicago, Ill., were having difficulty with seals in the hydraulic cylinders that provided pressure for the clamp on their bench vises. Main faults of the seal were very short life, a tendency to leak and poor pressure control.

As the seal was needed in an enclosed part of the unit not designed for continual servicing, a tight seal was required with greater than usual dependability. After a prolonged laboratory inspection period, QUAD-RINGS were chosen, because they corrected the previous faults and provided an efficient seal.

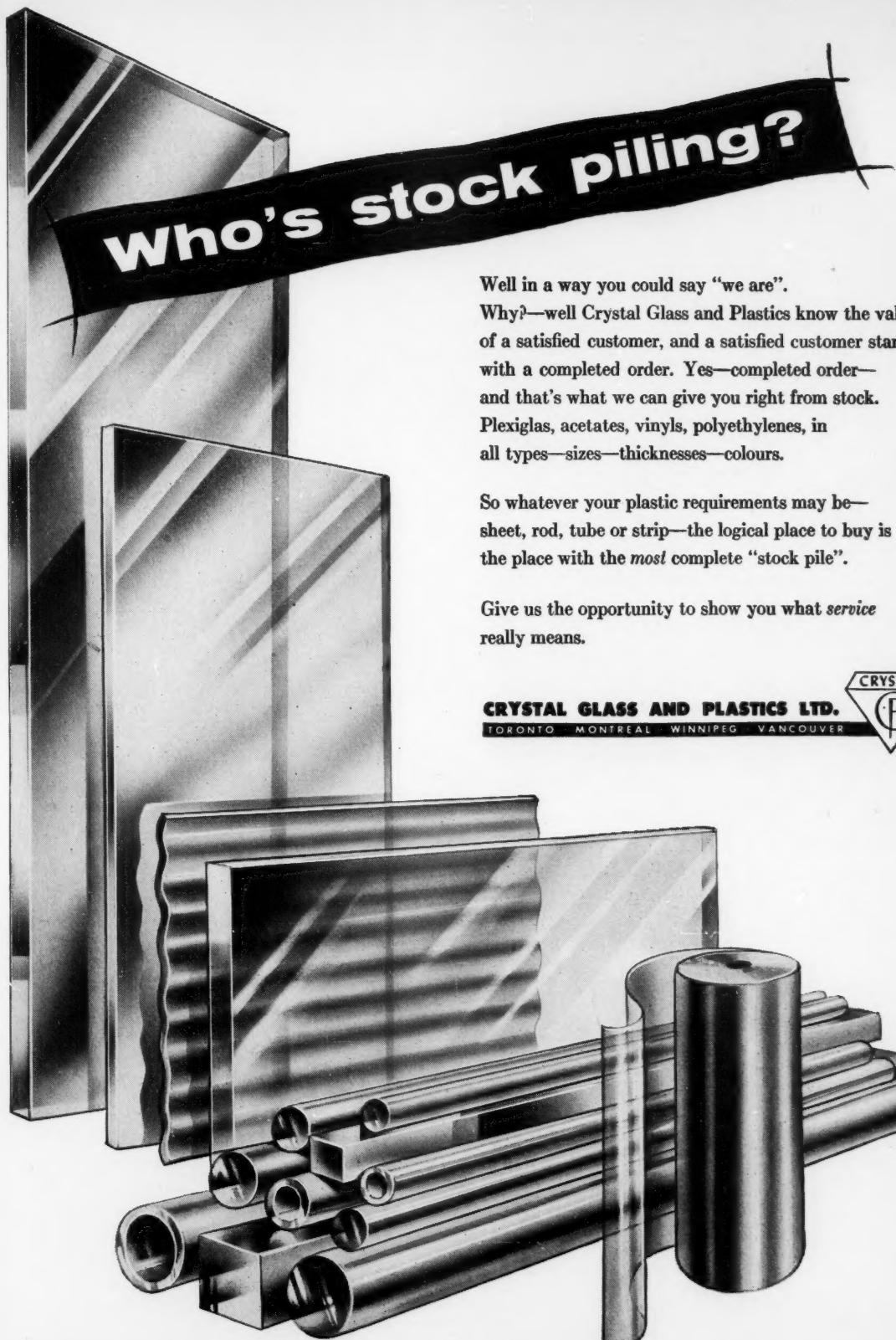
Results from field tests indicate that the QUAD-RING eliminates such sealing problems as spiral twist failures, parting line on sealing edges, torque leakage at low pressure differentials and rolling with pulsating pressure. The company also claims longer life because of reduced squeeze, and economy through reduced installation cost and ability to perform efficiently without extra fine finish and close tolerance.

Speed Reducers

SUGGESTIONS FOR installation and lubrication of speed reducers is given in engineering service bulletin 1L-155 of the WINSMITH, INC.

New Scintillation Phosphors

DETAILS ARE GIVEN in Bulletin No. 9 published by NUCLEAR ENTERPRISES LTD., of scintillation gels for internal counting of alpha and beta emitters, of boron, cadmium and gadolinium loaded liquid scintillators for neutron detection and other items in the same field.



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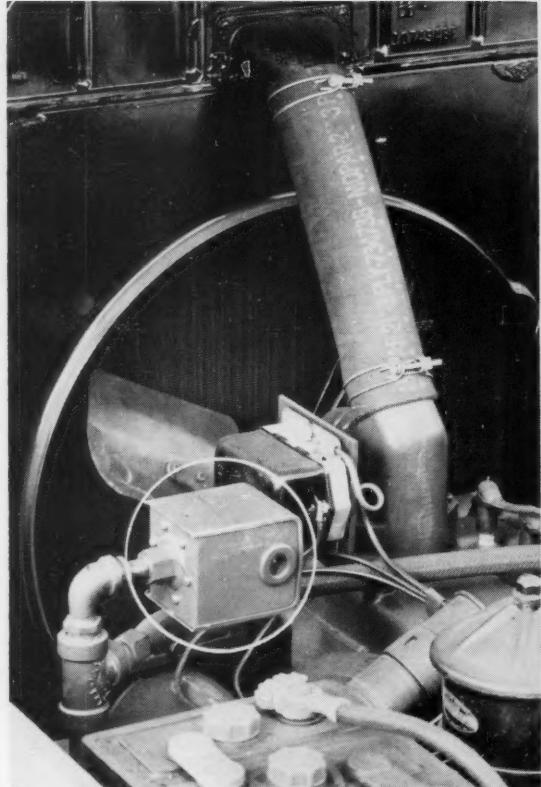


Design news in pictures

Some modern designs making news today



A new method by which industry can select, from a series of 21 standard building block components, the best electronic control system to regulate push-button manufacturing operations from remote points is illustrated here by John J. Smith, president of The Sparks-Withington Co.



The purpose of this overload warning signal (circled) is to warn the driver of an industrial truck, either by a signal light or a bell (optional), that the load he has just picked up is in excess of the safe operating capacity of his truck. This Lamson Mobilift signal can also save truck failures.



A new razor coming on the market will allow you to shave without water, lather or electricity. The two-ounce "Nylomat," brainchild of a Canadian inventor, is made almost entirely of nylon (because of its low coefficient of friction) measures just two inches across and fits into the pocket.



Machining teeth in large sprockets and gears is simplified by the process, Cogmatic Flame Machining, developed by Seaman-Andwall Corporation, Milwaukee, Wisconsin. It involves the precise control of a fast-cutting torch, moving on machined ways, guided by a special cam for control.

MISSING PAGES 71-72, READER SERVICE CARD

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Quotes

Points from current papers and speeches

THE TITLE OF A PAPER in the Proceedings of the INSTITUTION OF MECHANICAL ENGINEERS, Vol. 169, No. 33 by M. A. Jacobson is: Bending Stresses in spur gear teeth and proposed new design factors based on a photo-elastic investigation.

The paper embraces three related subjects: Photo-elastic measurement of stresses in spur gear teeth; interpretation of stresses so found to give revised strength factors for B.S. specification on the design of spur gears; and a tentative attempt to correlate the stresses found with fatigue-test results reported by various investigators.

The object of the paper is to propose the maximum safe bending loads that involute spur gears can be allowed to carry. The gears investigated are confined to those which can be generated by standard cutters conforming to the 20-deg pressure angle, B.S. basic rack, without causing either undercutting near the root or undue pointing of the teeth. The values proposed are based on a photo-elastic investigation carried out by the author under the guidance of Professor W. A. Tuplin, at the Post Graduate School of Applied Mechanics, Sheffield University.

Strength factors for spur gears are given in the form of charts. These factors embrace the whole possible range of spur gear combinations, both with and without addendum corrections.

To enable a rational assessment of strength to be made, a list of service factors, as well as a graph correlating bending-fatigue data for three classes of surface finish (ground and polished, shaved or hobbed) are given.

Use of Charpy tests

AN EVALUATION OF the significance of Charpy tests for quenched and tempered steels was given by P. P. PUZAK and W. S. PELLINI of the Naval Research Laboratory.

Crack - starter tests of various high strength steels have been conducted to determine the critical fracture transition temperatures at which welded structures, loaded in the presence of sharp, crack-like defects, may initiate or propagate brittle fractures. The test procedures establish three critical fracture transition temperatures related to the specific loading conditions required to initiate and propagate brittle fractures. The temperature interval of change from the

state of complete ductility (even under conditions of severe plastic deformation) to nil-ductility (such that brittle fracture initiation is possible upon reaching incipient yielding in the vicinity of crack-defects) is shown to be approximately 100 F for all the steels investigated. This interval was determined to be in the -200 to -100 F temperature range for the steels of highest notch ductility, and in the +100 to +200 F range for the steels of lowest notch ductility.

Correlation studies of Charpy V and Keyhole transition curves were presented. It was concluded that Keyhole curves deviate greatly from Charpy V curves for materials of this type. The nil-ductility fracture transition temperature in high strength steels is generally related to the 20/30 ft-lb temperature of the Charpy V energy transition curve. Fracture propagation is possible through elastic loaded material to temperatures corresponding to relatively high positions on the Charpy V transition curve. However, complete resistance to brittle fracture (scarcely tearing only) is obtained at temperatures on the upper-shelf of the curve.

A discussion was presented of the use of the critical fracture transition concept in design.

Structural welded designs

STRUCTURAL WELDED DESIGNS made without proper consideration for economical welding and erection can result in higher costs than riveted designs, stated OMER BLODGETT, LINCOLN ELECTRIC CO., in a lecture on welded joint design. Welded designs are lower in cost when properly made. To aid designers, engineers and fabricators make better structural designs, the author presented an analysis of basic loading conditions met in structural steel work and typical joint designs for these conditions which offer opportunity to reduce the cost of both fabricating and erecting.

Tin-rich solders

DETAILS ARE GIVEN in the QUARTERLY JOURNAL OF THE TIN RESEARCH INSTITUTE, No. 34, of how tin-rich solders are playing an important part in the development of printed circuits. Among their advantages are low melting point, good strength and excellent penetration. It is also stated that fusible alloys containing tin can be great time-savers in the making of molds for the injection

process. By using cooling coils, embedded in the fusible alloy molds, they can be used with some of the higher melting-point plastics.

An investigation into an interesting case of lack of adhesion between an electroplated coating and a tin-base die-casting showed that the trouble was due to the loss by diffusion of the plated flash of copper.

Titanium, zirconium and tantalum

THE CORROSION RESISTANT properties of tantalum, zirconium and titanium were reviewed, and progress in process applications presented by WILLIAM E. LUSBY, JR. before the Spring Symposium of the National Association of Corrosion Engineers. Fabricating know-how and industrial experience have progressed to the point that these metals can be accepted as reliable materials of construction. Additional fundamental research is needed, however, to understand the mechanisms of attack and passivity noted. The use of these metals can now be economically justified in many locations. Volume production, and the lower prices forecast for titanium and zirconium due to defense needs, will lead to a greater use of them in corrosion-resistant applications.

Nondestructive testing of welds

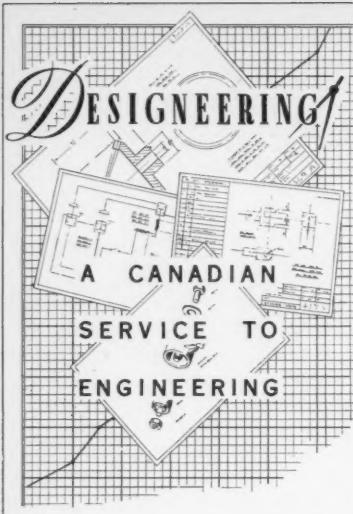
A GENERAL REVIEW of the various methods and techniques for the non-destructive testing of welds was given by W. J. McCONNAGLE of the Argonne National Laboratory. Special emphasis was placed in this paper on the application of these methods and techniques. The sensitivity, advantages, disadvantages and limitations of the different testing methods were pointed out.

The use of the ultrasonic shear wave technique and radiography for the examination of welds were discussed in detail. Correlations were made between ultrasonic and radiographic results and the use of standards and setting of standards considered.

Welded beam-column connections

A PAPER ON welded top plate beam-column connections by CYRIL D. JENSEN and R. FORD PRAY contains a method for computing the per cent restraint and the moment-rotation characteristics of any top plate and seated beam-column connection, provided the column is stiffened or has sufficient strength to eliminate local crippling. Proof is provided by tests made by the junior author. Also included was a tension test specimen suggested for testing new designs of top plates. Potentialities of the top plate type of connection were shown.

(continued on page 80)



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Fuel injection

(continued from page 64)

be delivered at any point in the line. If the fuel is sprayed above the throttle valve, icing is avoided. With additional energy supplied for atomizing the fuel, good atomization can be achieved over the entire speed range of the engine.

Carburetor injection systems have been used for many years in aircraft engines. The system for an automobile engine is basically the same.

Fuel is pumped from the supply tank into a special chamber in the carburetor. A pressure regulator positions the valve, which controls the fuel flow from this chamber to a second chamber. The regulator may be a combination of diaphragms that sense the air flow in the venturi section of the carburetor. It also measures the pressure in the fuel line across metering orifices.

The fuel is sent through metering orifices to the injection pump and then, in an automobile engine, to the inlet manifold or to the cylinder. Some means equivalent to an automatic choke or primer must be provided for enriching the mixture during cold starting, at idle and at full throttle.

No matter which type of fuel injection system is used, it seems certain that there are several advantages to be gained over a carburetor system.

Fuel injection permits more precise control of the amount and timing of fuel delivery than does a carburetor system. Carburetor systems limit high-speed, full-throttle operation because manifolds must be designed so that air flow velocity during idle doesn't drop so low that fuel settles out. But this design may allow extreme inlet pressure drop during higher air flows. Also, the hot spot and manifold heating device that assists carburetor vaporization during cold starting, heats up the induced air and reduces the mass air flow. So the amount of the charge which can be drawn into the combustion chamber of a carbureted system is limited. The result is that engine efficiency and maximum output are limited.

Fuel injection avoids this inherent manifold design problem by delivering the fuel to each cylinder in equal charges, and in just the right amounts. Since injection atomizes the fuel mechanically, there is no need for manifold heating. Because of a cooler manifold with cooler incoming air, volumetric efficiency is improved and more power is extracted from the fuel.

Engineers differ greatly over what can be expected from fuel injection, but there is fairly general agreement that it will result in some power increase (estimates range from 3 to 25%) and

(continued on page 77)

Metal Stampings

(continued from page 32)

The subdivision of formed components (sectional or built-up construction) must also be considered during the discussions of design modifications. Especially in the case of comparatively large objects, and those difficult to manufacture, sectional construction is very convenient.

Fig. 13 shows a workpiece produced by assembling three comparatively simple parts. This workpiece replaces a component, originally designed as a one-piece, integral compound-formed stamping (with two bends in two different planes), the production of which would be rather difficult and expensive and whose stock utilization factor would be very low. As a result of the savings realized by sectional construction, the extra expense of assembling the three parts, has been largely offset.

Very deep shells (higher than their diameters) are sometimes much cheaper if built up with a piece of tubing and an easily drawn (or even simply bent) bottom joined by some proper means, such as welding, seaming or riveting. This hint is especially interesting and useful in the case of non-circular shells (polygonal cross-sections).

Fig. 14 shows a wheel (pulley) which is composed of a couple of drawn parts and a short piece of tubing, all brazed together.

In addition to the savings in tooling and material, and the avoidance of difficulties in manufacture, there is another advantage in the composite construction method of boxes. This is the possibility of some standardization. In fact, by using the same end-plates (fig. 15), several sizes of the same kind of box can easily be produced, by changing only the length (L).

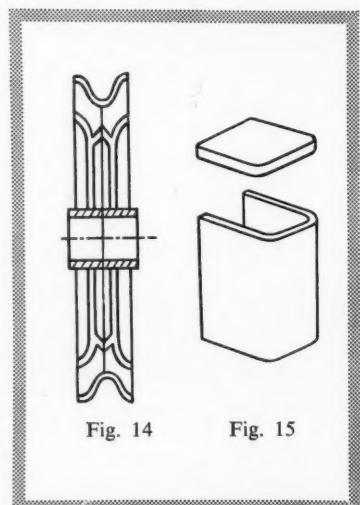
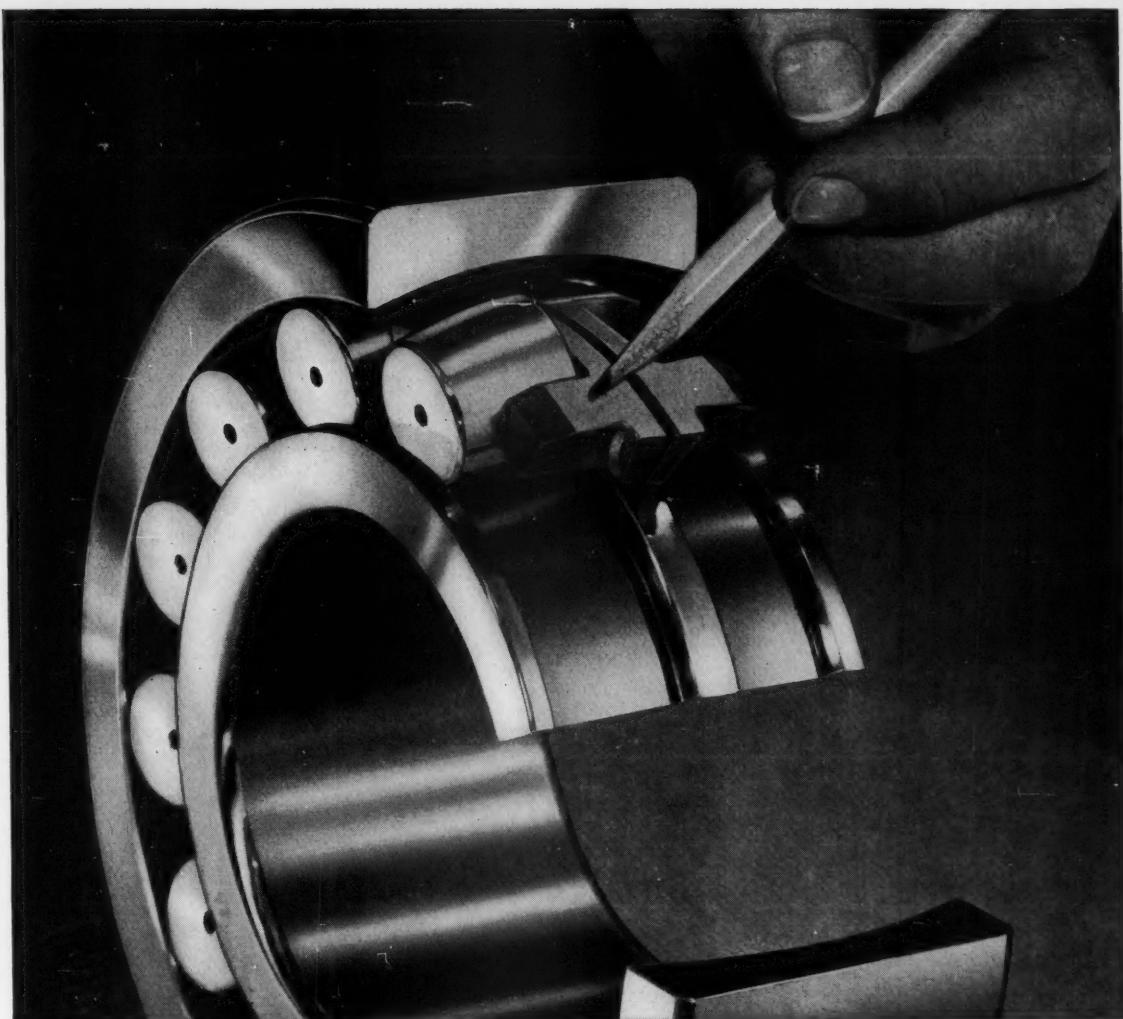


Fig. 14

Fig. 15

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Letters

Readers' viewpoints . . .

- With reference to the May 1956 issue of the "Design Engineering" magazine.

Could you please let us know who produces tapes and templates as shown on the front cover.

J. JOSEPHSON
J. Pollack-Josephson & Associates
Montreal Industrial Engineers

- On page 52 of "Design Engineering" issue, there is a description of the Mulard ultrasonic drill.

We are interested in obtaining complete information on the various models made, particularly of the larger sizes. This information should include price and delivery.

Would you please forward this request to the manufacturer.

EWAN D. BOYD
Adka Industries Ltd.
Vancouver, B.C.

- In the November issue of Design Engineering 1955, there was an article on Enjar resilient wheels.

We would be interested in Enjar wheels for use on mine cars, skip wheels and conveyor belt trippers.

It would be appreciated if you would advise us the manufacturers and any data that may be available in regards to this particular wheel.

B. M. FORSYTHE

The International Nickel Company
Copper Cliff, Ont. of Canada Ltd.

Tuck-away board

- We would like to inquire further with the manufacturers of Canadian sales representative on a Foldaway drawing board as displayed on pages 76 and 77 of the May publication of Design Engineering.

Could you direct our interest into the appropriate hands, or advise us by return mail, to whom we may direct our inquiry toward seeking further information.

We appreciate very much your prompt attention for which we extend our sincere thanks.

C. M. GALLIENNE, JR.

General Manager
Precision Rubber Products
(Canada) Ltd.

Ste. Therese de Blainville, Que.

Creativity in industry

- I was very much interested in the article in your May 1956 edition concerning the idea of developing more

creativity in industry. May I please be informed when the next meeting of this group of engineers will take place.

L. B. WALKER
Division Engineer
Canada Car & Foundry
Company Limited

Fort William, Ont.

- With reference to the article on pages 54 and 58 of DESIGN ENGINEERING May 1956, I should be glad if you would put me in touch with the organizers of the meeting on the future of Canadian engineering development.

JOHN W. WEBBER,
122 Argyle Ave.,
Ottawa. Apt. 3.

- Your article in DESIGN ENGINEERING, where you discussed the triangular diesel engine, reminded me of an aero engine design which I conceived back in 1940, in my home country Latvia.

I was chief engineer and designer of the Aircraft Division of a large electro-mechanical concern at Riga. By my projects a number of original aircraft types were developed. British and U. S. aero engines were used.

After the war started and engines were difficult to obtain, we considered our own engine development program. My idea was to use efficient, small size air-cooled cylinders and other standardized parts, and create a family of engines which would cover a possibly large power range (From 100 to 2,000 hp). Using this principle, the largest engine was a 36 cylinder, three crankshaft engine comprising 6 rows of 6 cylinders. It was intended to power a new 380 mph fighter (my 19th design). Unfortunately, neither the engine nor the fighter was realized, because of the Russian invasion of our country.

I came to Canada in 1948 with the intention to continue my work, creating new and original designs in aeronautical, automotive and industrial design fields, in which I have long and successful experience.

The things, however, did not work out too well for me in this respect and no wonder that I am beginning to look toward the land of "unlimited opportunities" to the south of Canada.

Your excellent magazine was a real eye-opener for me because until now I did not realize that there are people who are seriously fighting for creativity and original designs in our Canadian industry.

I would like very much to participate in discussions of this matter. Please do not forget to notify me when something is planned for Montreal.

Yours very truly,

KARL IRIBITIS,
AFCAI, IAS,
5360 Victoria Ave.

Montreal, Que.

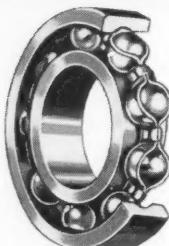
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Fuel injection

(continued from page 72)

a little better fuel economy (5 to 15%). Without hot spots in the manifold, the possibility of backfiring through the induction system is reduced.

Lower engine operating temperature will decrease the engine mechanical octane requirements too. So lower octane fuels may be used, or spark timing can be advanced considerably without causing detonation. And the compression ratio can be increased for better output and economy.

Since atomization and distribution of the fuel are not dependent on induction air, higher end-point fuels can be used. There is, however, still some difference of opinion on this point. Some researchers report a drop in power output when using such fuels.

Since the fuel system is pressurized, high vapor pressure fuels may be used. Higher octane ratings of these fuels require less tel and promote cleaner burning and less combustion chamber deposits. However, some researchers have been unable to discover any marked improvement in the vapor-handling properties of a fuel injection system.

Since fuel injection gives more uniform distribution of the fuel to each cylinder, a very lean mixture is possible at part throttle, with subsequent fuel economy. For starting, idling and full throttle, the mixture can be enriched accurately to the most efficient ratios.

Some injection systems respond very quickly to engine requirements. So an automatic device to cut off fuel during deceleration can be used without affecting engine performance. This will reduce the amount of unburned hydrocarbons to be forced out of the exhaust and contribute to smog. Some fuel economy is achieved, too.

Experiments indicate that in an engine with fuel injection, peak torque occurs at about 500 rpm lower than with a carburetor. This is particularly advantageous for cars with automatic transmissions. On the other hand, there are several disadvantages inherent with fuel injection that have not, as yet, been entirely solved: Fuel lines may corrode and clog with dirt more easily than in carburetor systems. Hot starting may be difficult unless an adequate control device is provided. Control devices for acceleration must also be provided to overcome the slight time lag caused by the use of an air throttle control. The initial cost of fuel injection systems at present is from two to four times the cost of a carburetor system.

The ability of fuel injection designers to devise means of overcoming these

(continued on page 79)

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One model has a pin plunger actuator to permit mounting through a panel. There is a slot on top of the switch case where auxiliary actuators

tors can be secured in place by the mounting screws.

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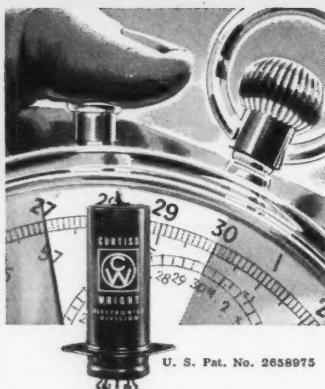
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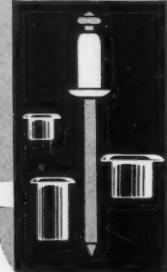


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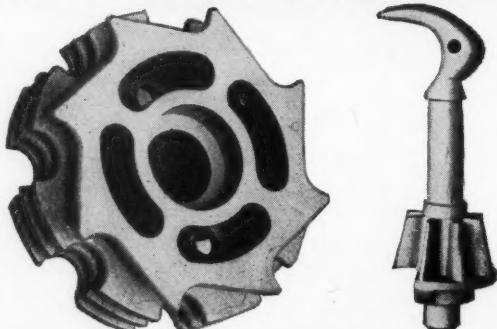
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Fuel injection

(continued from page 77)

disadvantages will determine the future of fuel injection systems for passenger cars. The various fuel injection systems on the market today have different characteristics which will determine their applications. If initial cost is not too important — as in racing cars or trucks, where maximum torque and best fuel economy are paramount — individually timed and metered injection directly into the combustion chamber may be preferred. For stock passenger car engines, where low cost is important, low-pressure manifold injection may be more satisfactory. Some engineers favor the injection carburetor system for passenger cars.

In the meantime, research and development work is continuing. For the most part there is agreement that fuel injection will give some worthwhile benefits if we are willing to pay for them. Also, engines specifically designed to use fuel injection will give considerably better performance than carburetor engines merely adapted for fuel injection.

The key to a practicable system is the fuel injection pump. So many companies are concentrating on improving that. Hartford Screw Machine Co., makers of the Roosa Master fuel injection equipment, has recently developed a new pump which can be used for gasoline engines. It is a single-cylinder, inlet-metering, distributor-type pump.

The Petroleum Chemical Division of du Pont has been doing research to anticipate fuel problems that may come up with fuel injection systems. Using an American Bosch, high-pressure system on a 1954 V-8 Lincoln passenger car, they found that the injection system improved horsepower about 7% and required a little lower-octane gasoline than the same engine with a carburetor.

Both Bendix Products Division and Thompson Products have fuel injection research projects under way. Bendix, it is reported, is working with low-pressure units, whilst Thompson is investigating both high and low pressure systems.

A recent report from researchers at the Pennsylvania State University tends to confirm opinions of those who prefer continuous injection instead of timed injection for low-cost systems. They discovered that the continuous injection system is not very sensitive to nozzle design. A small quantity of fuel was injected into the chamber, where it was ignited by the spark plug. The remainder of the charge was injected continuously into the intake port with the amount varying with the engine load demands.

Current experience with fuel injection systems indicates that they will not have

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A uniform spray of cutting oil is applied directly upon the close interface between tool and work piece.

TAMPER-PROOF SPRAY CONTROLS

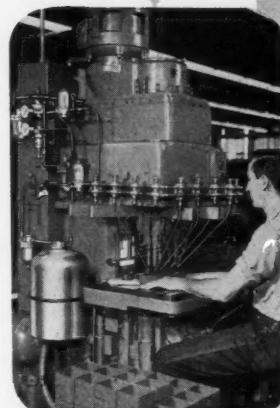
Individual, tamper-proof controls for both air and cutting oil can easily be adjusted to deliver exactly the right spray—coarse or fine.

FASTER COOLING

Because of the larger fluid surface area of the spray and the expansion of compressed air at the point of application, heat is dissipated quicker.

COMPACT, CONVENIENT SIZE

A space only 14" x 20" x 7" is all that is required for a 2-gallon unit.



30% MORE OUTPUT

On tapping machine at Square D Company, SPRAY-LUBE, replacing former flood system, eliminated excess of lubricant and time lost for cleaning parts. Results: Greatly improved working conditions and 30% increase in production.



\$250 A YEAR SAVED PER MACHINE

On gear hobbers at Cullman Wheel Co., Norgren SPRAY-LUBE increases tool life, provides cleaner, safer working conditions and saves \$250 a year per machine in lubricant costs alone.



OUTPUT DOUBLED
SPRAY-LUBE doubled output on vertical turret lathe for O.K. Rubber, Inc. Surface cutting speed increased from 45 to 75 rpm; welding of chips to tool eliminated; galling of work pieces ended.



TWO TIMES LONGER CHAIN LIFE

At Wagner Electric Corp., Norgren SPRAY-LUBE lubricates chain drive on degreasing machine. As a result, noise has been eliminated and chain life doubled.

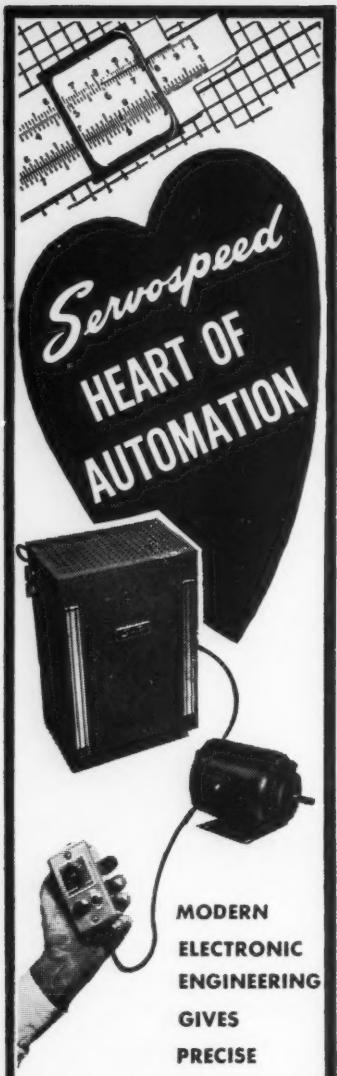


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Quotes

(continued from page 71)

AN INSIDE SEAM WELDER, equipped with a 40 ft boom, enables personnel to weld inside seams in manufactured pipe as small as $8\frac{1}{2}$ in. ID without the use of backing strips or back chipping, so states FOSTER WHEELERS "HEAT ENGINEERING." It produces a weld of highest quality that will pass all code tests. This machine eliminates the use of high priced and difficult-to-obtain forgings because headers and pressure piping can now be fabricated of heavy high quality plate. The machine has proved so successful that it is also used to weld inside seams of larger pressure vessels where manual welding could be accomplished.

The welder is a submerged arc d-c constant potential welder operated from a movable control console. In the welding of longitudinal seams the welder starts the weld on a test plate attached to one end of the cylinder. The controls are set and the welding head travels under its own power and direction a maximum distance of 42 ft without major adjustment by the operator. A guide wheel keeps the welding wire in the welding groove at all times. In the welding of circular seams the boom remains stationary and the pipe or pressure vessel is revolved at the precise speed required by the inside seam welder. There are some limitations to the length the boom can be extended in the welding of small diameter inside circular welds.

In submerged arc welding, the molten flux floats to the surface of the weld metal where it solidifies. Unlike manual welding, however, this slag is easily removed by brushing or tapping.

Blade Root Fixings

INVESTIGATIONS INTO blade root fixings of high temperature steels is dealt with in a SULZER TECHNICAL REVIEW.

The progress in mechanical engineering which has led in the last few years to much lighter designs of aircraft and land vehicles is due in the main to two factors: An improvement in the materials used and a much better adaptation of structural designs to the properties of these materials. In the case of aircraft and land conveyances, the engineer's main problem has been alternating stress at room temperature.

Much the same trends are apparent in the use of steels at high temperatures, except that our knowledge is here less firmly founded. Again, the principal problems are to develop better materials and to find improved designs which will enable the strength properties of these materials to be fully utilized. It has turned out, for instance, that an improvement in creep properties at high temperature

is usually accompanied by an increase in embrittlement and sensitivity to notching, so that a satisfactory compromise can only be reached by the selection of the most suitable structural designs.

These considerations are particularly important in connection with the attachment of blade roots to turbine discs, and Sulzer Brothers have therefore carried out a large number of tests with the aim of throwing some light on the basic relationship between structural design and strength.

The investigations have taken the form of long-time tests on plain and notched specimens and on various models of blade-root fixing. The results of the tests on plain and notched specimens can be explained with the aid of a working hypothesis linking up to Ludwick's theory of the embrittlement of metals at room temperature. This has made it possible to find at least a qualitative explanation of the influence of material properties on embrittlement and to clear up a number of points which had hitherto been obscure.

The tests carried out on models of blade roots have shown that, in assessing the strength of blade-root fixings, it is necessary to take account not only of the results of creep tests on plain specimens but also of embrittlement, which can be investigated only in tests on notched bars. It has also been found that the design of the indentations in the blade root plays an important part in deciding the strength of a fixing, and that certain high-temperature metals, which are subject to embrittlement, can only be used if the indentations are given the most favorable form. *

Fuel injection

(continued from page 79)

much effect on the characteristics of automobile gasolines for some time. Since there are no warm-up problems with fuel injection systems, perhaps the 50% distillation point of automobile gasoline can eventually be increased, and the oil refiner will be able to use more low-boiling and high-boiling materials in gasoline. This will increase the amounts of fuel that can be refined from a barrel of crude oil.

It is doubtful, however, whether present fuel injection systems will be able to handle higher boiling materials without running into difficulties from engine deposits, sparkplug fouling and crankcase dilution.

Certainly, before refiners can take advantage of the broader fuel requirements, they will have to wait until there are enough fuel injection cars on the road to make it worth their while. *

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950
951
952
953
954
95

Advertising index — July

100	Aeroquip Canada Limited	6
101	Aluminum Co. of Canada Ltd.	IFC
102	Amalgamated Electric Corp. Ltd.	58
103	Avro Aircraft Ltd.	2
104	Bach-Simpson Ltd.	54
105	Canada Iron Foundries Ltd.	9
106	Canadian Allis-Chalmers Ltd.	15
107	Canadian General Electric Co. Ltd.	20, 64
108	Canadian SKF Ltd.	7
109	Canadian Steel Improvement Ltd.	65
110	Crystal Glass & Plastics Ltd.	69
111	Curtiss-Wright Corp.	78
112	Deloro Smelting & Refining Co. Ltd.	78
113	Designeering	72
114	Dominion Fasteners Ltd.	21
115	Du Pont Company of Canada Ltd.	17
116	Garlock Packing Co.	66
117	Goodyear Tire & Rubber Co. Ltd.	61
118	Hamilton Gear & Machine Co. Ltd.	51
119	Heim Company	8
120	Herring Co. Ltd., John	76
121	Industrial Fine Castings Ltd.	78
122	International Nickel Co. of Canada Ltd.	22, 23
123	Lyman Tube & Bearings Ltd.	11
124	Minneapolis Honeywell Regulator Co. Ltd.	77
125	Minnesota Mining & Mfg. Co. of Canada Ltd.	26
126	Morse Chain Co.	12
127	Noranda Copper & Brass Ltd.	10
128	Norgren Company	79
129	North American Cyanamid Co.	59
130	Northern Electric Co. Ltd.	19
131	Ohmite Manufacturing Co.	14
132	Parker Rust Proof Co. Ltd.	16
133	Polymer Corporation Ltd.	4
134	Precision Rubber Prod. (Canada) Ltd.	81
135	P.S.C. Applied Research Ltd.	63
136	Saginaw Steering Gear, Div. General Motors Corp.	57
137	Servospeed	80
138	Shawinigan Chemicals Ltd.	55
139	Sperry Gyroscope Ltd.	13
140	Standard Tube & T. I. Ltd.	52 and 53
141	Superior Tube Co. Ltd.	67
142	Timken Roller Bearing Co.	OBC
143	Torrington Co. Ltd.	75
144	Torrington Mfg. Co. Canada Ltd.	24
145	Union Carbide Canada Ltd.	IBC
146	United Shoe Machine Co. Canada Ltd.	78
147	Weatherhead Co. of Canada Ltd.	18

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81

Editorial

And not a minute too soon!

At long last something has actually been done about forming a society of Canadian design engineers.

Two weeks ago a small group of engineers got together to discuss the framework and the steps necessary to form a society. As a result, it was decided to go ahead and a committee was set up under the chairmanship of James D. Orr, of Orr Associates. Elected to the executive committee were Paul Dilworth (secretary), Burton Avery of Orenda Engines, Roy Jackson and Alexander Barrie.

As to what the society should be called was not so easy, but one name that was bandied around was The Canadian Society of Design Engineers (CSDE). Other suggestions included the Canadian Association of Design Engineers, the Canadian Society for Creativity in Design and so on, *ad absurdum*.

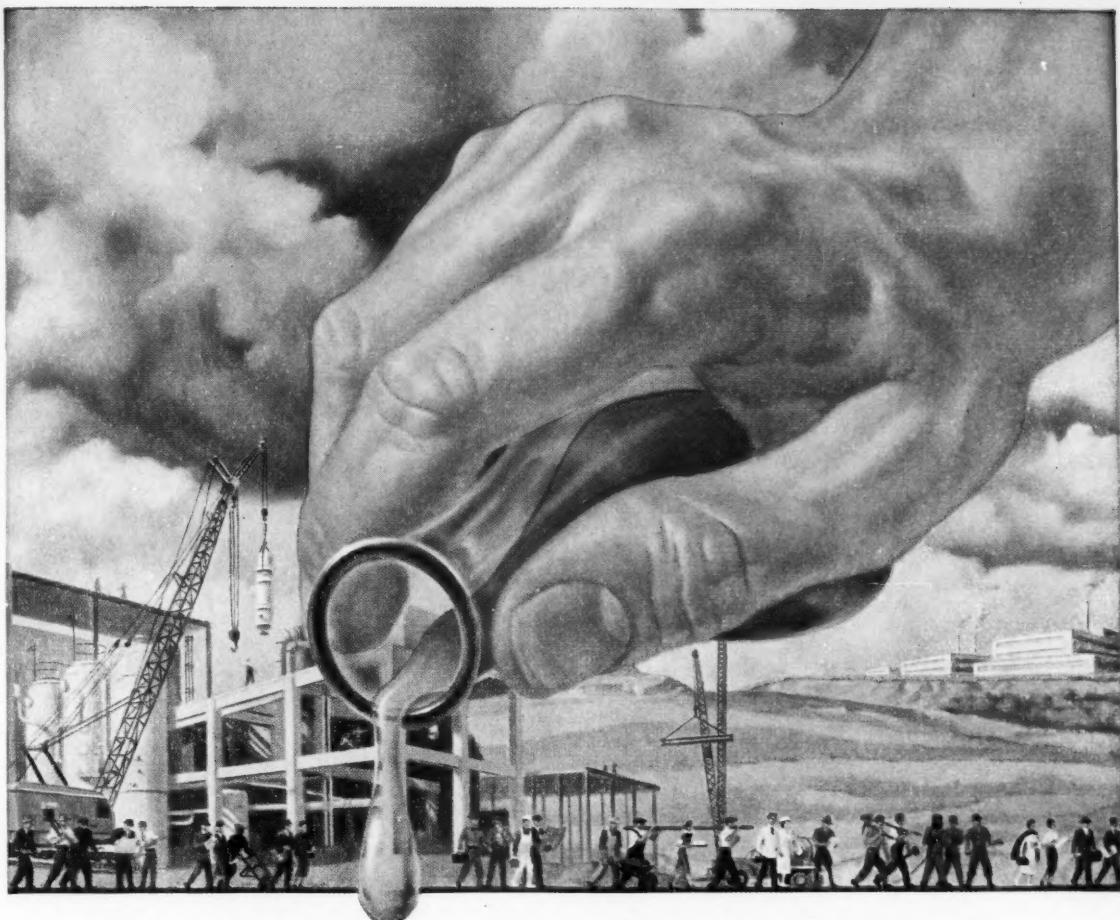
The aims of the society are to foster more original design in Canada by promoting the science of creativity: to give the various types of design engineer an opportunity of getting together to discuss their common (or uncommon) problems: and to allow an exchange of knowledge in their fields through competition, social gatherings and joint study meetings.

There has been a lot of talk about creativity in the last few months and the subject has been well covered in the pages of DESIGN ENGINEERING from time to time. As Dr. Lewis Sillcox said in his recent Wallberg lecture at the University of Toronto, "We must try to develop imaginative men who can conceive of the unknown places . . ."

It was made abundantly clear at the Design Engineering Show in Philadelphia this year how important is this aspect of engineering in its many ramifications. The fact that 13,000 engineers turned up instead of the expected 8,000 showed the interest there is in it.

The time is certainly ripe for the formation of a society and DESIGN ENGINEERING would like to be one of the first to congratulate the founders and wish them every success in their new venture.

William Morse



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How TIMKEN bearings give Richards-Wilcox cranes a smooth ride, reduce manufacturing costs

To give this underrunning single-bridge crane a smooth ride and keep it on the go, Richards-Wilcox Canadian Company, Limited, uses 32 Timken tapered roller bearings in the crane end truck wheels.

This smoother operation is possible because Timken bearings virtually eliminate friction. One reason: they're designed by geometrical law to have true rolling motion. And they're accurately manufactured to deliver the low friction this design makes possible.

Cranes like this Richards-Wilcox operate smoothly under heavy working conditions because they have the

extra load-carrying capacity provided by Timken bearings. This is the result of full line contact between rollers and races. And since they carry both radial and thrust loads, making thrust devices unnecessary, Timken bearings need less space, allow more compact designs that result in lower manufacturing costs.

Because Timken bearings hold housings and shafts concentric, closures are more effective. Dirt stays out—lubricant stays in. And maintenance and lubrication costs are held to a minimum.

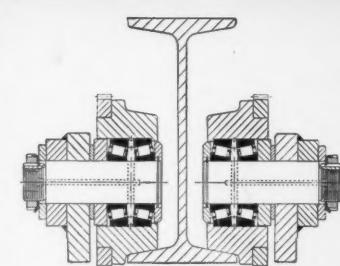
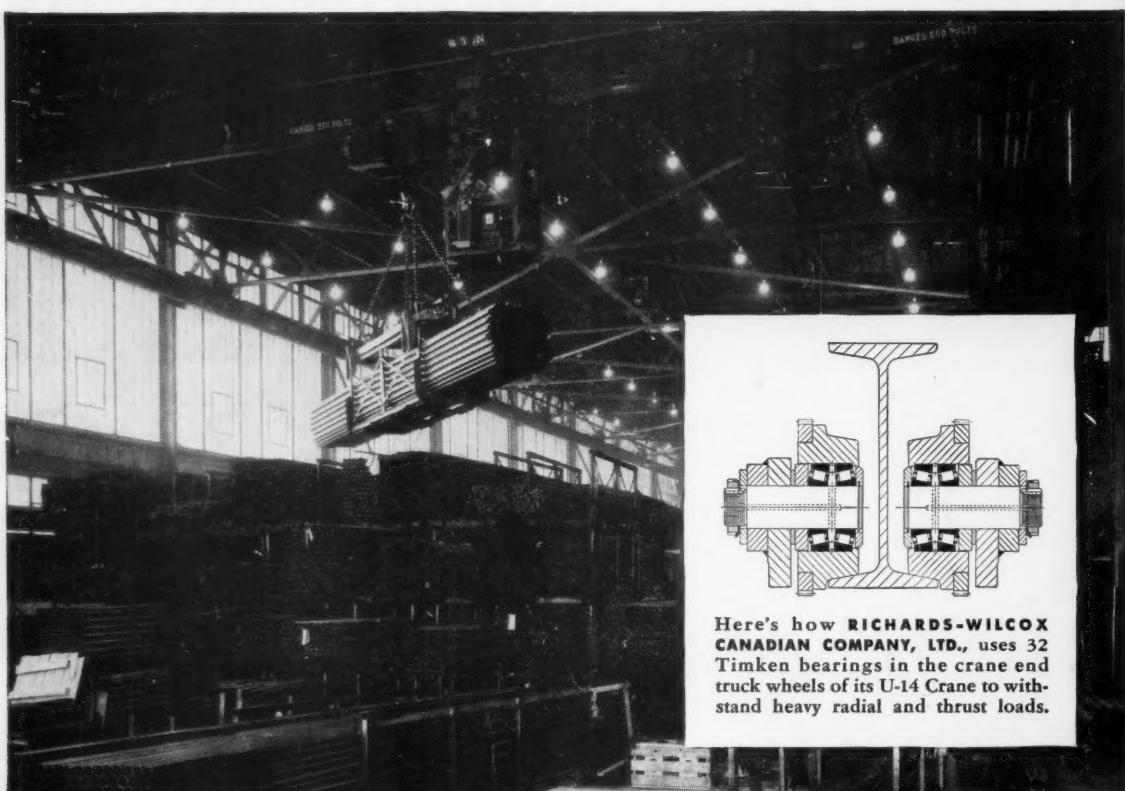
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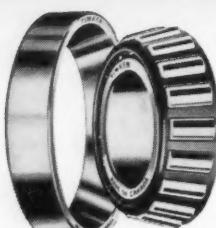
Whether you build or buy equipment, you can have all these advantages if you specify Timken bearings. Look for the trade-mark "Timken", stamped on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. CANADIAN PLANT: St. Thomas, Ontario. Cable address: "TIMROSCO".



This symbol on a product means its bearings are the best.



Here's how RICHARDS-WILCOX CANADIAN COMPANY, LTD., uses 32 Timken bearings in the crane end truck wheels of its U-14 Crane to withstand heavy radial and thrust loads.



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